Design Analysis of Reverse Acting Grate for Solid Waste Mixing in a Combustion Chamber

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Background

The drying, volatilization, and combustion phenomena during the travel of the solid waste fuel over the grate depend on a large number of parameters

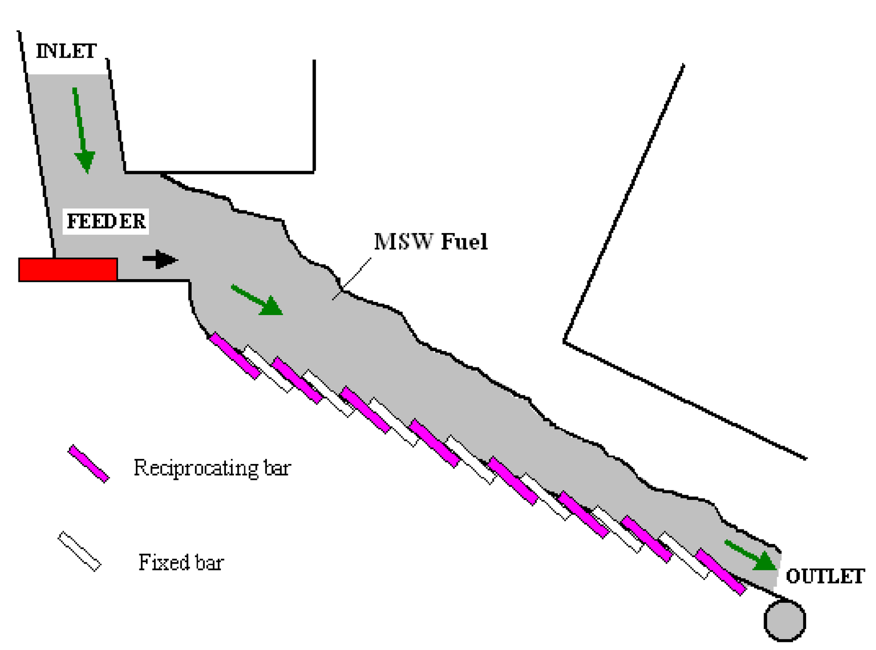
Reverse Acting Grate System in a Waste-to-energy Combustion Chamber

- **The physical and chemical properties of the diverse particles in MSW that vary widely in size, shape, density, moisture, chemical composition, and calorific value; and also the design of the grate and combustion chamber.**

Objectives

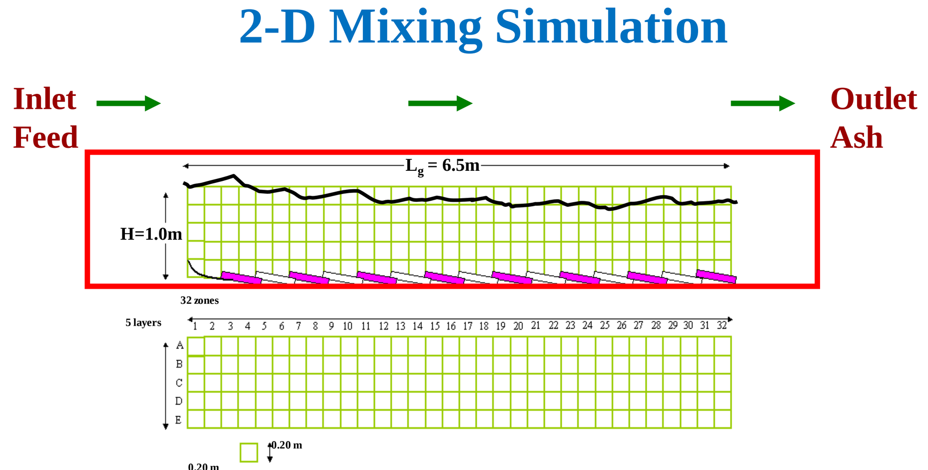
Providing a better tool for understanding effects of solid flow and mixing by a traveling grate

- **Developing a mathematical model to characterize and quantify flow and mixing processes of the highly non-homogeneous MSW.**
- **Simulating the behavior of solid waste particles with transport and combustion phenomena.**



Stochastic Modeling

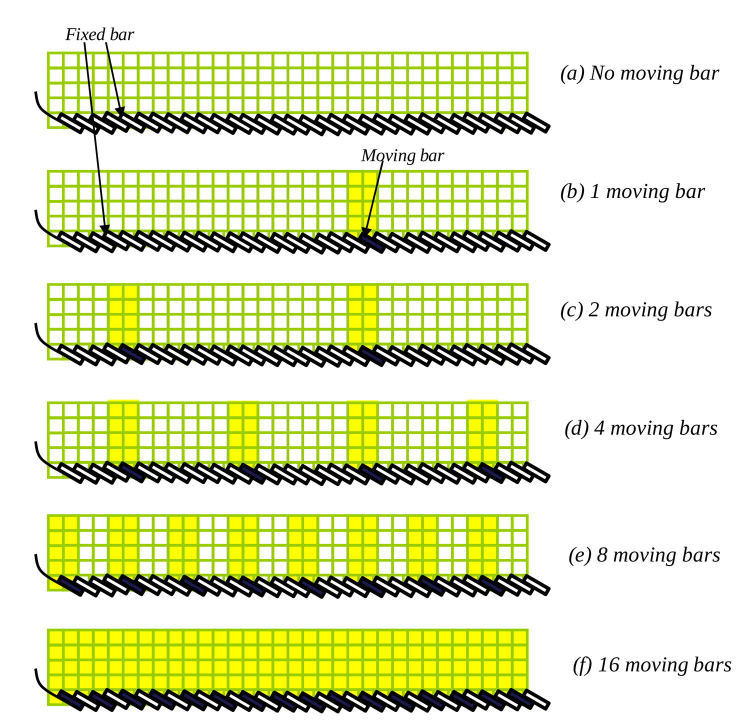
2-D Mixing Simulation



- **Each cell is divided into 5 layers (Layer A top of bed and Layer E next to the surface of grates)**
- **Interchange of particles between successive cells : the first cell of the model represents the inlet and the cell 32 represents the position next to the ash bin.**

Moving Bars

The position of the moving bars (0, 1, 2, 4, 8, and 16 bars) at the reverse-acting grate:



Transition Matrix

The rule governing the particle migration through the system is represented by a matrix:

Current Distribution = (Initial Distribution * *n* th power of Transition Matrix)

$$\boldsymbol{S}(n) = \boldsymbol{S}(0)\ \boldsymbol{P}^{n}$$

162 cells

$$\boldsymbol{S}(0) = [1 \quad 0 \quad \cdots\cdots \quad 0]$$

Initial Distribution of MSW

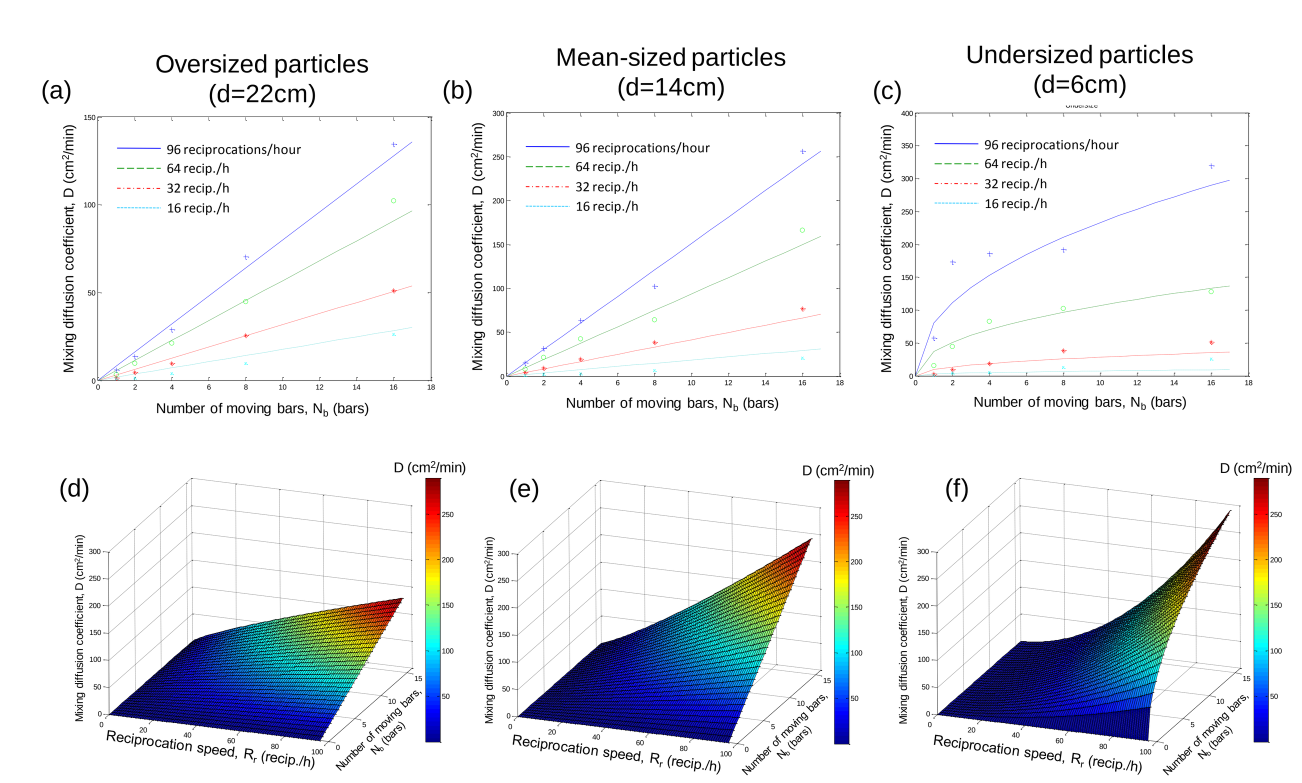
162

$$\boldsymbol{P} = \begin{bmatrix} p_{11} & \cdots & \cdots & p_{1,162} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & p_{j,k} & \cdots \\ p_{162,1} & \cdots & \cdots & p_{162,162} \end{bmatrix} \quad 162$$

The Transition Matrix

Calculation Results

The relationship among the mixing diffusion coefficients D, number of moving bars Nb, and Reciprocation speeds Rr



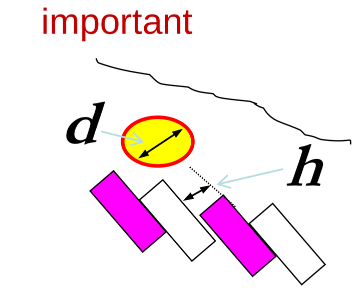
Discussion

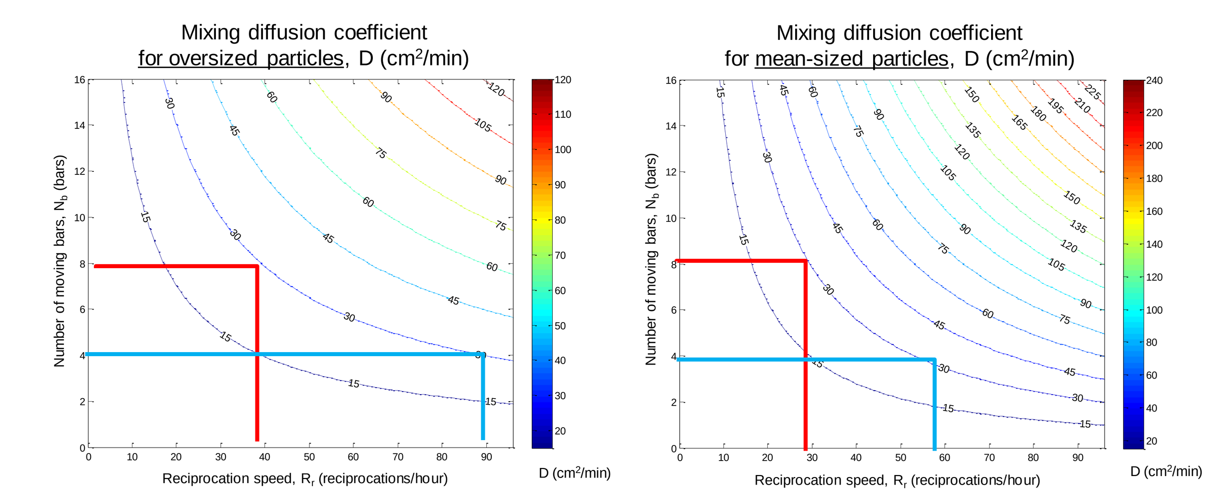
Mixing Diffusion Coefficients, D

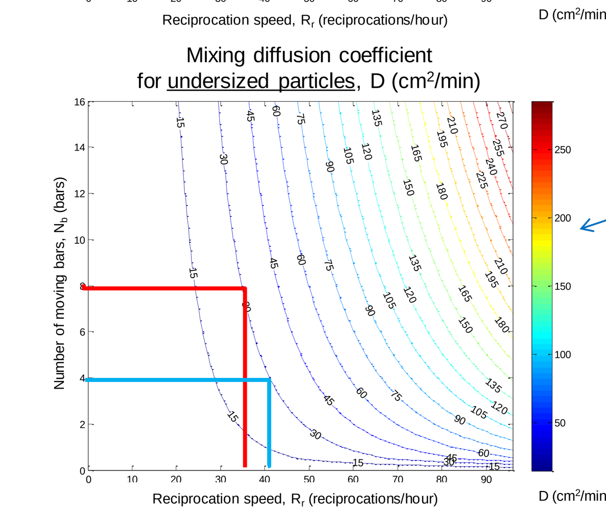
$$D(N_b, R_r, d, h) = \begin{cases} a\left(\frac{d}{h}\right)^2 \cdot N_b^{\left(\frac{d}{h}\right)} \cdot R_r^{\left(\frac{h}{d} - b\right)} & if\ d < h \\ a\left(\frac{d}{h}\right)^2 \cdot N_b \cdot R_r^{\left(\frac{h}{d} + b\right)} & if\ d \geq h \end{cases}$$

a, b: constant
d: diameter of MSW particle (cm)
h: height of moving bars (cm)
De: mixing diffusion coefficient (cm²/min)
R_r: reciprocation speed of moving bars (recip./hour)

The ratio *d/h* is very important







Contours of mixing diffusion coefficients, D with different numbers of moving bars N_b, and reciprocation speeds R_r for (a) oversized, (b) mean-sized, and (c) undersized particles.

Conclusion and Future Work

2-dimensional model of MSW mixing on the Martin reverse-acting grate (RAG) with different number of moving bars (0-16 bars) was developed for quantifying mixing degree and number of moving bars.

The study resulted in the following conclusions:

a) The number of moving bars (from 0 to 16 bars) of a reverse-acting grate results in a net effect of increasing the mean residence time of small and medium sized particles by 24 % and 6%, respectively, while decreasing that of large particles by 13%.

b) Calculations of the mixing diffusion coefficient *D* with different numbers of moving bars and reciprocation speeds showed that the oversized particles are mixed more <u>when number of moving bars equipped increases</u>, while undersized are mixed more <u>when reciprocation speed increases</u>.

Future work:

a) **Experimental Work: using an infrared camera (FLIR E40), test heat transfer among MSW particles in a backed bed above the reverse acting grate of physical model**

b) **Mathematical Work: integrating a heat transfer model to the stochastic mixing model.**

Infrared Camera (FLIR E40)