Chapter 7

Simulation

7.1 System Simulation

After having tested the validity of the model by comparing with the experimental data, the system model developed in Chapter 3 is used to simulate the effect of the operating variables on combustion efficiency. The particle sizes of lignite and its size distribution in the feed are the same in all simulation runs. The concentration of burning char in the bed was assumed to be 0.1 % of total bed weight calculated from Eq. 3.4.49 and Eq. 3.4.50. The total elutriation and overflow of combustible losses simulated are expressed in percentage. According to the experiments, the oxygen concentration in the bubble is assumed to be 19 % of air volume.

The operating variables of superficial velocity, feed rate, bed temperature are varied, the combustible losses required are simulated from the model. In order to confirm the simulated trends of the effects of operating variables on combustible losses, the experimental data and the trends are compared.

7.2 Simulated Results and Discussion

The simulated effects of operating variables on combustion efficiency are discussed below.

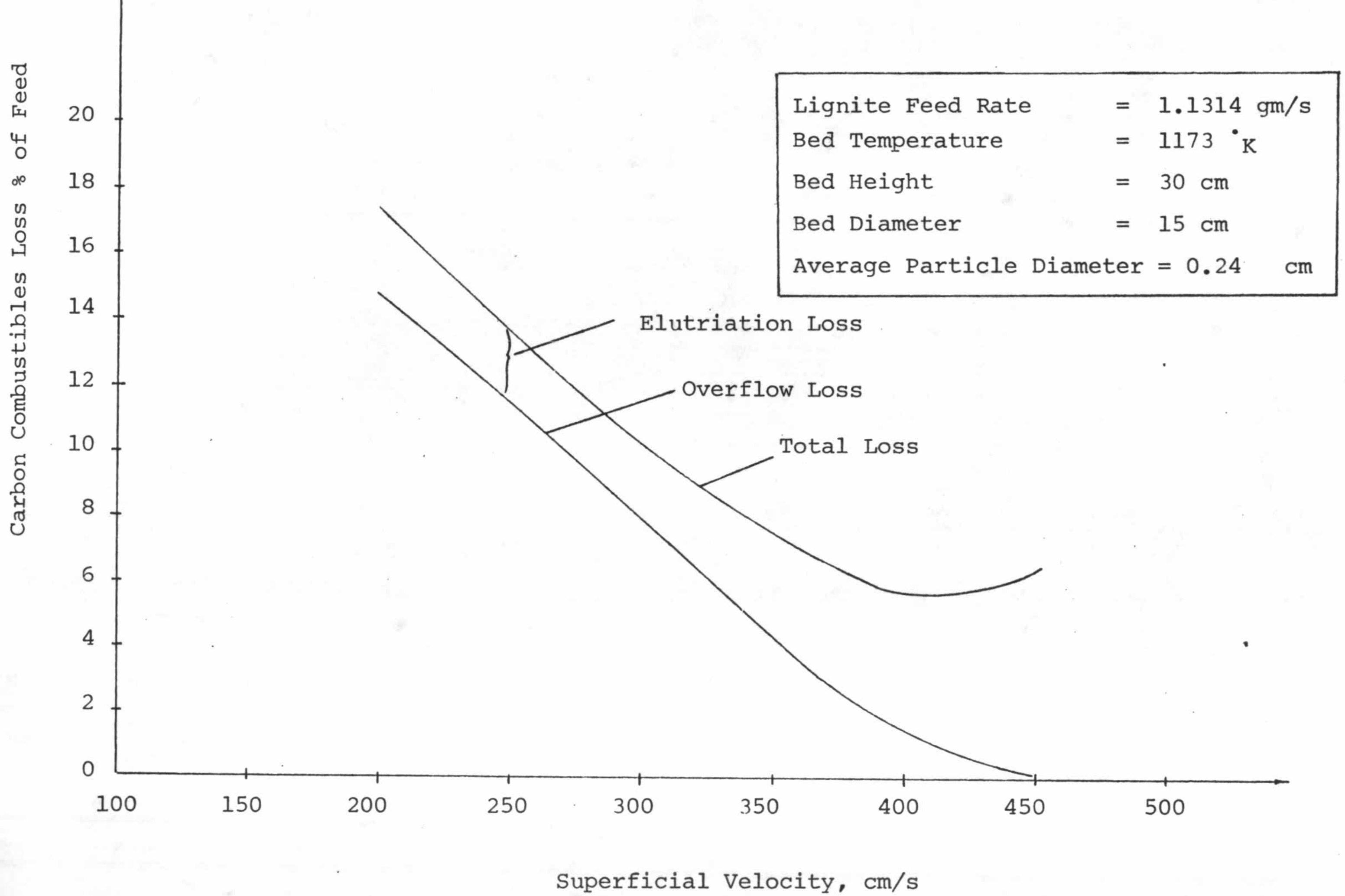
7.2.1 Superficial Velocity

The effect of superficial velocity on combustible loss from the combustor is shown in Fig. 7.1 and Table 7.1, for bed temperature of 900°C and average lignite particle diameter of 2.4 mm.. The elutriation loss increases as the superficial velocity increases, but the overflow loss decreases as the superficial increases. Hence under the certain conditions, the simulated optimum superficial velocity affecting the minimum total combustible loss is 4 m/s., and the optimum ratio of superficial velocity to minimum fluidizing velocity is about 5, for carbon combustion efficiency about 94 %.

Table 7.1 Effect of Superficial Velocity on Combustible Loss (from experiment)

Superficial Velocity Cm/s	Bed Temp °C	Excess Air %	Total Combustible Loss %
308	881	209	9
376	995	243	3
393	931	277	6

Fig. 7.1 The Effect of Supeficial Velocity on the Carbon Combustibles Loss from the Combustor
(with Constant Feed Rate, Bed Temperature, and Bed Height)



7.2.2 Bed Temperature

The effect of bed temperature on combustible loss for fixed superficial velocity, coal feed rate and bed height, is shown in Fig. 7.2 and Table 7.2. From Fig 7.2, the overflow loss decreases as bed temperature increases, the carbon combustion efficiency varies from about 88 % to 93 % for a temperature range of 750°C to 1000°C. The higher the combustion efficiency, the higher the temperature is. Generally the higher emission of NO is caused by the higher bed temperature, and the bed temperature used is about 900°C for NO emission less than 500 PPM. But in these experiments the NO emission is very low (see Table 6.2), even though the bed temperature increases to 1050°C.

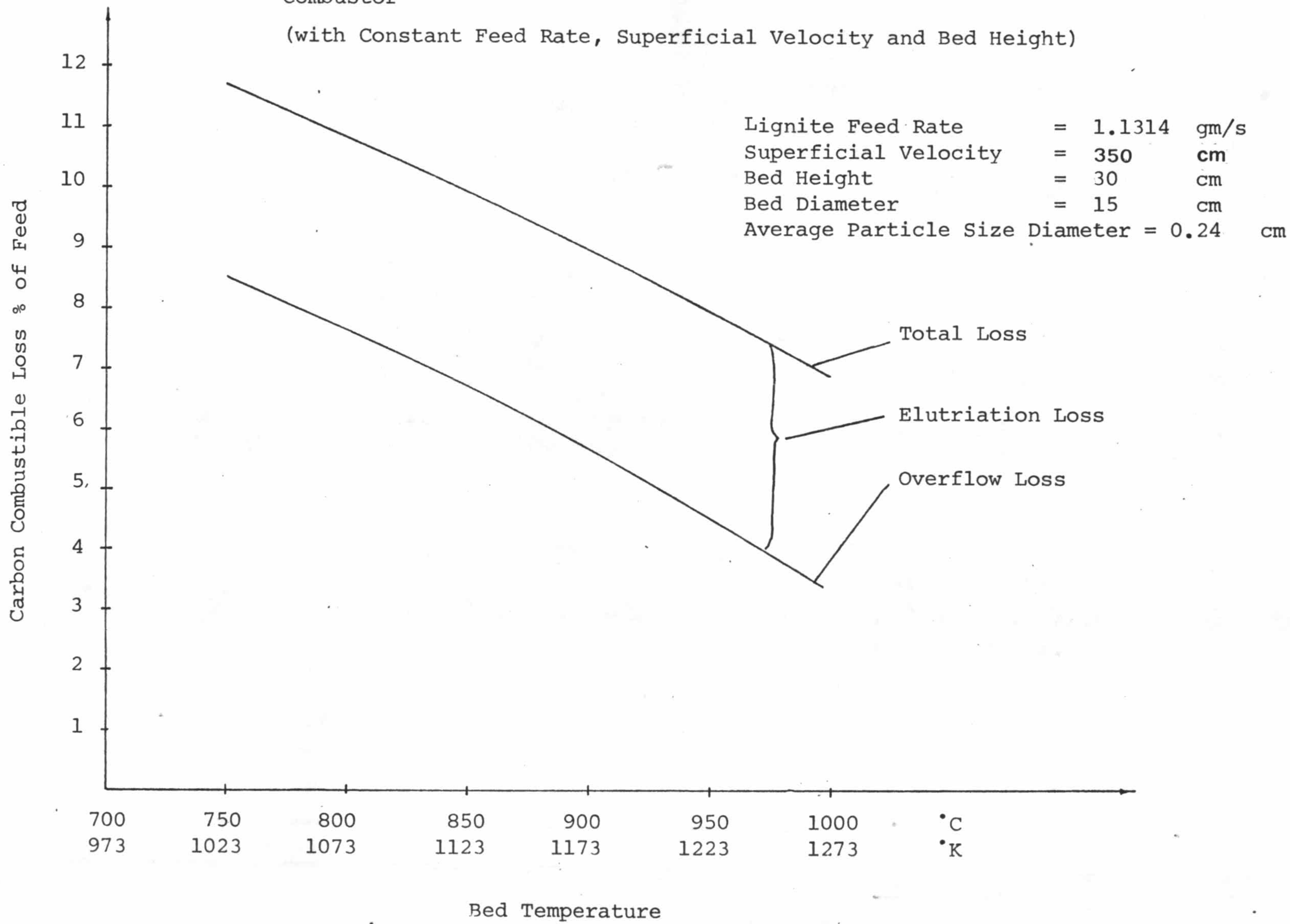
From Fig. 7.2, it is noticed that the elutriation loss is rather steady because of the fixed superficial air velocity.

Table 7.2 The Effect of Bed Temperature on Carbon Combustible Loss (from experiment)

Bed Temperature °C	Superficial Velocity cm/s	Coal Feed Rate gm/s	Elutriation Loss %	Overflow Loss %	Total Loss %
964	330	1.67	3.69	3.14	6.83
1057	394	1.67	4.21	1.54	5.75

Fig. 7.2 The Effect of Bed Temperature on the Carbon Combustibles Loss from the Combustor

(with Constant Feed Rate, Superficial Velocity and Bed Height)



7.2.3 Coal Feed Rate

Fig 7.3 and Table 7.3 provide the effect of coal feed rate on the carbon combustible loss with constant superficial velocity, bed temperature and bed height. The overflow loss increases rapidly for small increase of coal feed rate. The elutriation loss is small. Hence the carbon combustion efficiency depends mainly on overflow loss. Fig 7.4 shows that the average residence time of burning char particle in the bed affects the overflow carbon combustible loss directly. The more the residence time, the more carbon combustion efficiency is.

The average residence time of burning char particle ($\bar{t}$) is calculated from

$$\bar{t} = \frac{W_{cl}}{F_o}$$

where W_{cl} = weight of burning char particles in bed

F_o = coal feed rate

If the weight of burning char particles in bed is fixed, the residence time is affected by the carbon coal feed rate.

From Table 7.3, the residence time of the bed should not be less than 7 seconds for high carbon combustion efficiency (about 95 %).

Table 7.3 Simulated Average Residence Time of Burning Char Particles in the Bed with Constant Bed Temperature, Superficial Velocity and Bed Height.

No	Coal Feed Rate F_o gm/s	Overflow Carbon Combustible Loss %	Elutriation Carbon Combustible Loss %	Carbon Combustion Efficiency %	Weight of Burning Char Particles in Bed gm	Average Residence time s
1	0.5	0	5	95	2.9	13.0
2	1.0	0	5	95	5.8	6.6
3	1.5	28	2	70	6.6	4.4
4	2.0	50	0	50	6.6	3.3
5	2.5	60	0	40	6.6	2.6
6	3.0	67	0	33	6.6	2.2

Bed temperature = 1173°K, Superficial velocity = 400 cm/s, Average coal particle size in feed = 2.40 mm.

Bed height = 30 cm.

Fig. 7.3 The Effect of Coal-Feed Rate on the Combustibles Loss from the Combustor (with Constant Superficial Velocity, Bed Temperature and Bed Height)

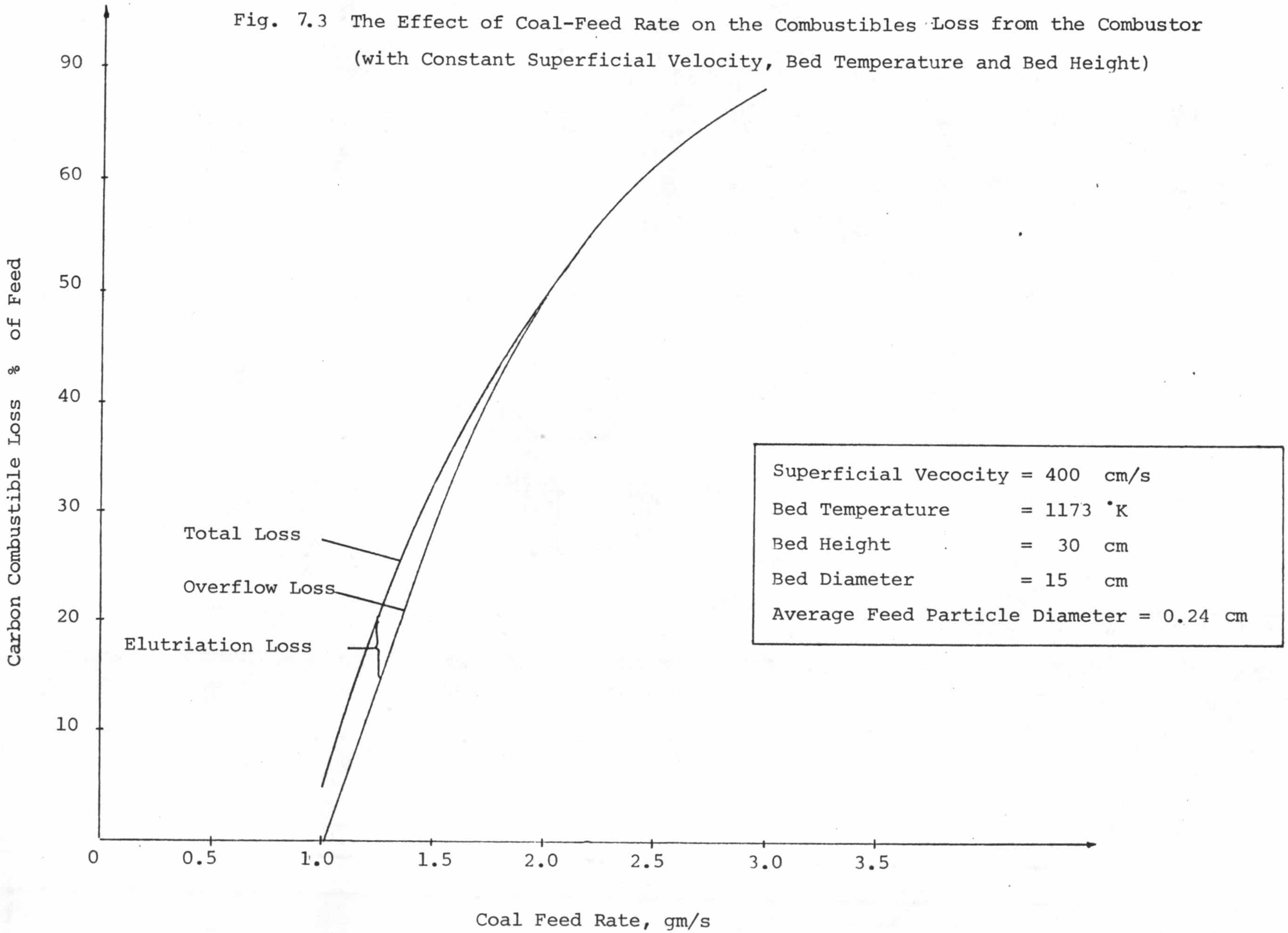


Fig. 7.4 Average Residence Time of Burning Char Particles in the Bed and Carbon Combustion Efficiency