SIMULATION OF REACTIVE TWO-PHASE TURBULENT FLOW WITH HOTTEL ZONAL METHOD OF RADIATIVE HEAT TRANSFER

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Radiative transfer dominates the heat transfer in many high-temperature systems like fossil fuel fired furnaces and boilers. Accurate simulation of radiative transfer is then of crucial importance for prediction of the thermal performances. In the last fifty years, several radiative heat transfer methods have been developed: discrete transfer radiation model [1], spherical harmonic P1 approximation [2], discrete ordinates method [3], [4], non-equilibrium diffusion model [5], [6], effective-emissivity approximation [7], Monte Carlo method [8] and various zonal methods [9], [10], [11]. The Hottel zonal method is intended as a realistic scheme for calculation of radiant heat exchange with respect to spatially distributed heat release.

Direct interchange areas are calculated using well known procedure [11]. Direct exchange areas of close zones are obtained by numerical integrations. Yamauti principle is used in calculation of direct exchange areas, [12]. Total exchange areas are obtained using reflected fluxes, when original emitter is surface or volume zones. Matrix equations of reflected fluxes, nedeed for total exchange areas, are solved by Crout algorithm. Table 1 shows sums of the some of the direct and total exchange areas.

Table 1: Calculated and exact values of some of the direct and total exchange areas

Direct exchange area			Total exchange area		
Zone No.	Sum	Exact value	Zone No.	Sum	Exact value
11s	6.2498	6.25	11s	5.937	5.9375
71s	6.2433	6.25	46s	5.94049	5.9375
256s	6.2478	6.25	432s	4.68799	4.6875
378s	6.2451	6.25	441s	4.69217	4.6875
18g	5.1471	5.18125	22g	5.14111	5.18125
219g	5.1347	5.18125	461g	5.12807	5.18125
478g	5.1323	5.18125	285g	5.13445	5.18125

s - surface zone, g – volume zone

Unknown temperatures of volume zones are found from convective heat transfer term, while unknown temperatures of surface zones are found from heat transfer through combustion chamber wall term, through iterative procedure. Comparison of experimental results and results of modelling is shown in the Figure 1, for temperatures at the furnace exit plane.

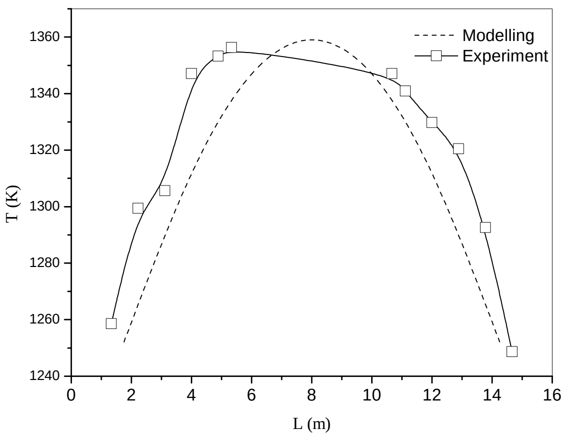
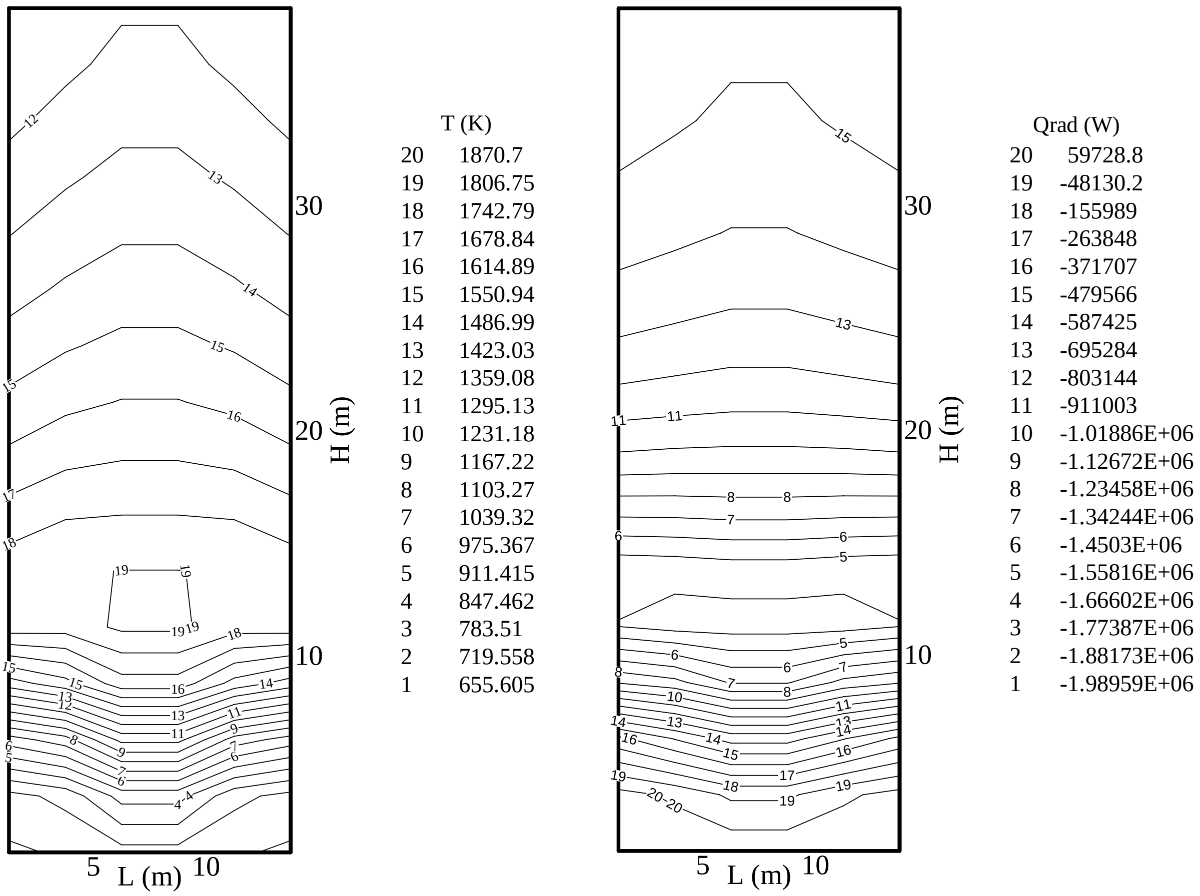


Figure 1. Comparison of experimental results with results of modelling

Since the agreement of the experimental and modelling results is acceptable, model is used to reveal the temperatures and rate of radiative heat absorptionof the volume zones. These results are shown in the Figure 2.



a) b)

Figure 2. a) Temperature profiles in the furnace, b) Rate of radiative heat absorption

Hottel zonal method is successfully applied to find source term due to radiation in the enthalpy equation. Comparison of measured temperatures and results of modelling showes acceptable agreement. This results enables us to further apply Hottel zonal method to determine the source term due to radiation in the enthalpy transport equation of the control volume computation method. Since this method includes matrix equations of big dimensions, application of this method requires considerable computer performances. The enormous and unexpected growth in available computers performances enable overcome this problem.

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