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Monitoring regenerative steel reheating burners using an intelligent flame diagnostic system

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ABSTRACT

The present paper describes the use of an intelligent Flame Monitoring System on regenerative steel reheating burners based on direct measurement and analysis of the flame radiation signals. A series of experiments were conducted on a 500 kW furnace fitted with two burners firing in a regenerative manner. The experiments covered a wide range of burner operating conditions including variations in the burner firing-rate and excess air levels. Gas supply to one of the burners was manually reduced in order to simulate burner imbalance. The flame radiation signals were acquired using a fibre-optic based optical instrument incorporating broad ultraviolet, visible and infra-red photodiodes. The correlation between the dynamic flame signals with respect to the excess air level and nitrogen oxides emissions were made using neural network models following off-line analysis of the acquired signals using different signal processing methods, to yield a set of flame features. The present work indicates that the measurement of flame radiation characteristics, coupled with advanced data modelling techniques such as neural network, provides a promising means of monitoring and optimising burner performance.

1. Introduction

Industrial steel reheating typically is accomplished in large furnaces with as many as 50 burners. The furnace is divided into zones each with multiple burners to ensure efficient and even heat transfer to the steel billets. The burners in each zone are generally supplied from a common manifold that delivers both the combustion gas and air to each burner. However, generally there is no metering to an individual burner and this results in a potential for burner imbalance, lower than ideal combustion efficiency and elevated nitrogen oxides (NO_x) and carbon monoxide (CO) emissions [1].

Flame diagnostics using a variety of sensors have been recognised as a means to optimise combustion processes in furnaces [2–5]. The general consensus is that measurement of the flame characteristics provides first hand diagnostic information, as the flame represents the core of the combustion system and therefore largely determines the outcome and quality of the combustion process. Consequently monitoring flame characteristics potentially allows corrections to non-optimum burner operating conditions to be made. The main challenges to the development and subsequent deployment of flame diagnostic instrumentation are often practical aspects related to;

a) cost
b) limitations of installation, particularly with regard to retrofit
c) reliability and durability

Some work with a commercially available infra-red flame detector, similar to that used on utility power generation burners, coupled with advanced data analysis techniques has had some success at controlling a pilot-scale pulverised coal fired burner [6].

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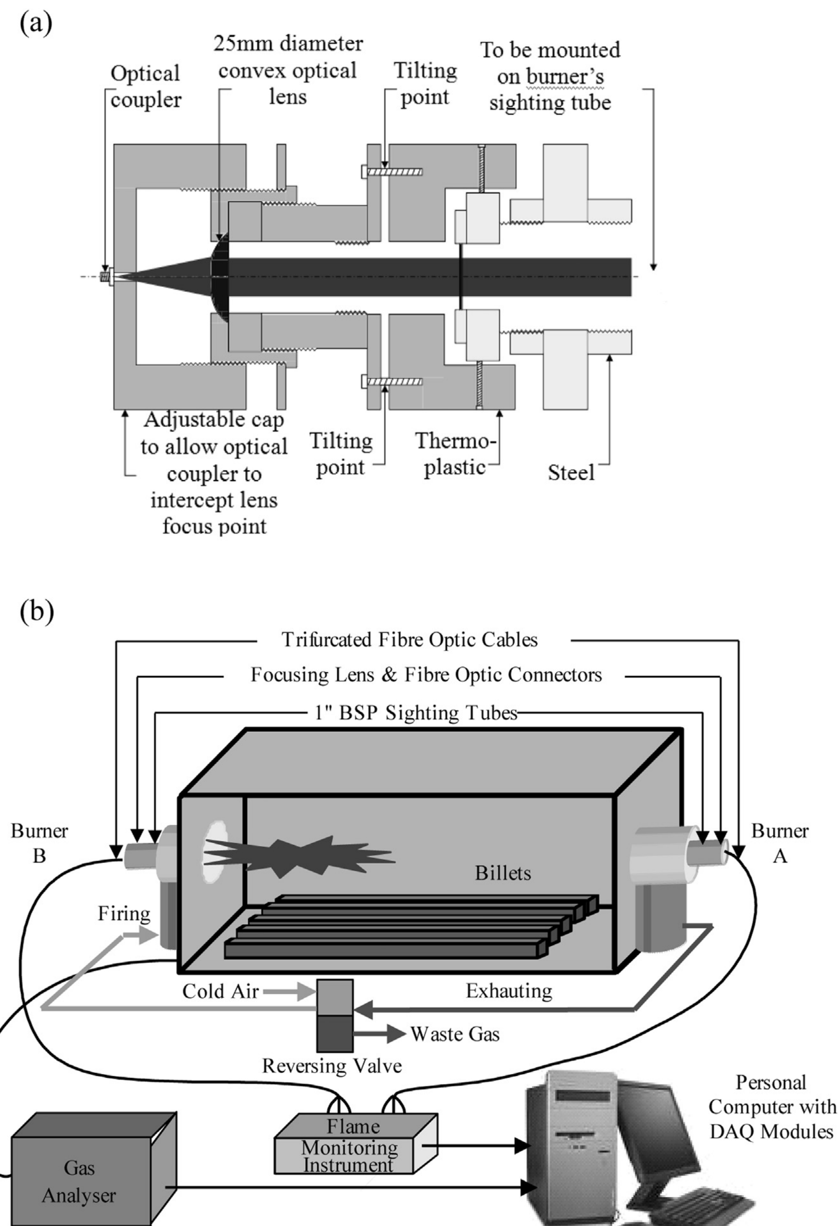

Fig. 1. Schematic of the pilot-scale furnace and instrument layout at Tata STC: (a) thermo-plastic holder with focussing lens; (b) regenerative setup.

Table 1
Summary of test conditions at Tata Steel STC.

Test number	Burner load (kW)		Excess air (%)	
	Burner A	Burner B	Burner A	Burner B
1–24	350	350	5, 10, 15, 25, 35 & 45	5, 10, 15, 25, 35 & 45
	275	275	5, 10, 15, 25, 35 & 45	5, 10, 15, 25, 35 & 45
	200	200	5, 10, 15, 25, 35 & 45	5, 10, 15, 25, 35 & 45
	325	325	10 & 25	10 & 25
	300	300	10 & 25	10 & 25
	250	250	10 & 25	10& 25
25	350	350	5	5
26	350	325	5	13.1
27	350	300	5	22.5
28	350	250	5	47
29	350	200	5	83.8
30	350	350	25	25
31	350	325	25	34.6
32	350	300	25	45.8
33	350	250	25	75
34	350	200	25	118.8