Combustor Concept for Industrial Gas Turbines with Single Digit NO_x and CO Emission Values

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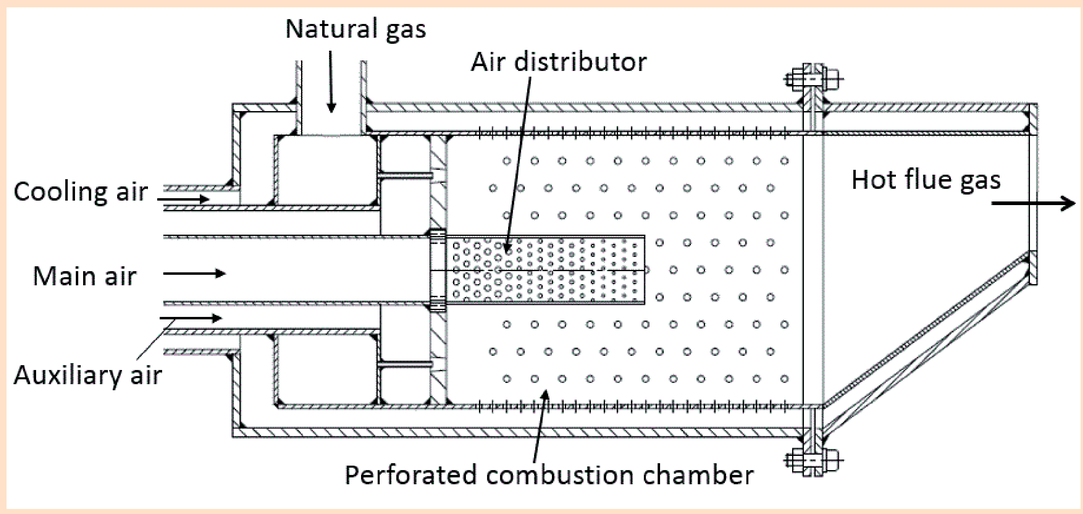
Objectives

Development of a simplified combustor concept for industrial gas turbines which is able to ensure a stable combustion and low pollutant emission at different thermal loads.

Combustor Concept

The base design of the new combustor consists of the so-called COSTAIR burner (continuous air staging with internal recirculation), as well as a compact combustion chamber with a perforated wall and an outside casing. The Figure below illustrates the design of the new gas turbine combustor.



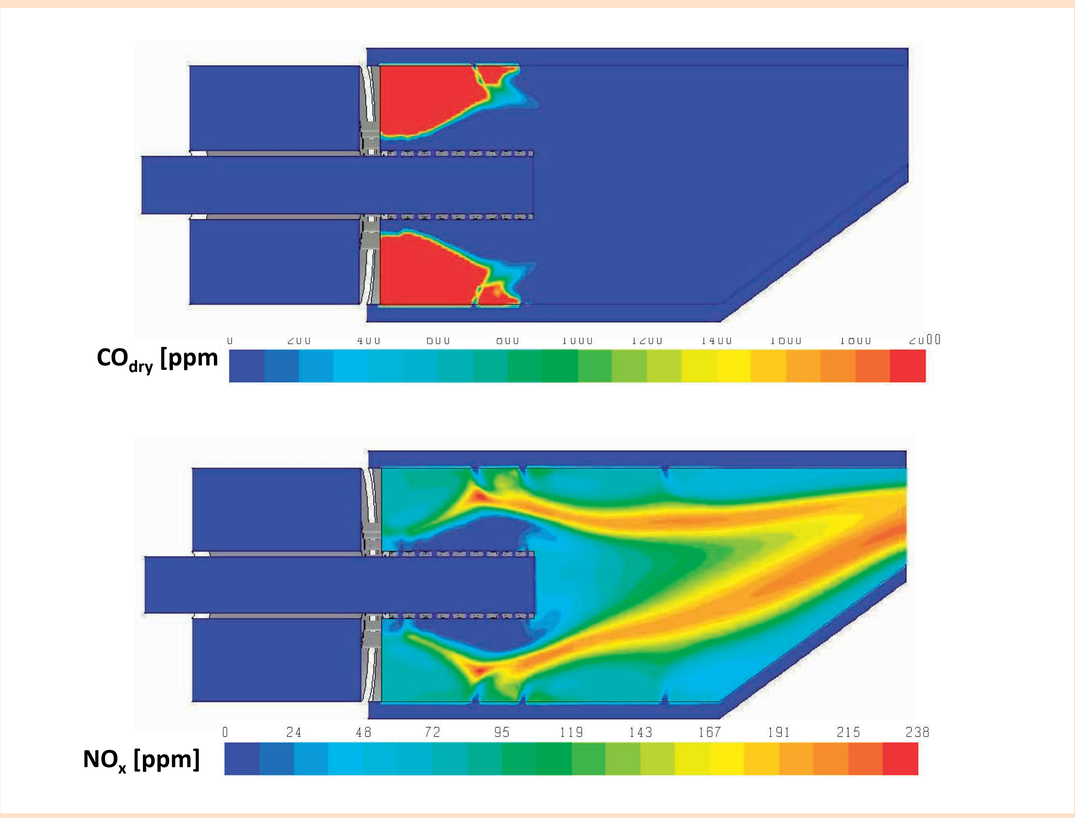
Schematic design of the new gas turbine combustor

Combustor Operation

The Main air is introduced through the holes of the air distributor into the combustion chamber in stages, leading significantly to NO_x reduction. By mixing of the auxiliary air into the natural gas before entering the combustion chamber, a high momentum is generated at the gas nozzles improving both the mixing process inside the combustion chamber and consequently the combustion stability. Both flows cause a large internal recirculation zone contributing to a full burnout. In combination with an optimized air distributor and cooling air holes, single digit for NO_x and CO emission values are expected.

CFD Optimization

The optimization and modification of the new combustor concept were carried out by numerical simulations followed by experimental investigations. The burner load was set to 225 kW at atmospheric pressure; the other operating parameters were chosen to represent typical gas turbine conditions as follow: gas type: natural gas; gas temperature 25 °C; gas pressure 1 bar, gas flow rate 24.3 Nm3/h; air temperature: 555 °C; total air ratio: 1.2 - 1.5. Typical results for NO_x and CO emissions are shown in the figure top right.



CFD results: Typical field distribution of CO and NO_x emission values for the new combustor

Experimental Results

The combustor design with best CFD results was selected for validation by experimental tests. Manufactured combustor shown aside was then tested at GWI test rig under similar conditions as in the CFD simulation. Table below shows an extract from achieved results for two burner loads and different air ratios.

View inside the gas turbine combustor

T_{air} = 530 °C, $T_{flue\ gas}$ ≈ 1400 °C							
Test		Measurement				@ 15 % O_2	
no.	P [kW]	O_2 [vol.%]	λ	CO [ppm]	NO_x [ppm]	CO [ppm]	NO_x [ppm]
10	157,8	12,7	2,4	18	30	13,0	21,7
11	157,8	13,6	2,7	12	10	9,7	8,1
12	157,8	13,7	2,7	19	13	15,6	10,7
13	157,8	14,3	2,9	29	30	26,0	26,9
16	231,44	11,0	2,0	15	13	9,0	7,8

Conclusions

- Numerical simulations helped to find a simplified and optimized combustor configuration suitable for gas turbine operation conditions
- Experimental investigations proved a stable combustion performance and single digit values for NO_x and CO emissions

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