It remains a challenge in gas turbine development to obtain low-NOx emissions as government regulations become more and more stringent. In this study low-swirl burners are adapted such that they become suitable for gas turbine application [1]. These burners are known for their extremely low-NOx levels and are already applied in atmospheric applications. The NOX reduction of more than 50% can then be achieved in gas turbine power generation which is responsible for a major part of the global energy conversion.

The rate of combustion in premixed natural gas flames is to a large extent controlled by the level of turbulence. To elevate the turbulence level in low-swirl burners so-called fractal grids are applied. These grids are obtained by truncating a self-similar fractal pattern at some level of refinement [2]. A parametric study of fractal-grid-generated turbulence containing 24 different grids with variation in grid patterns, solidity and range of embedded scales was conducted. First, a rod-stabilized, V-shaped flame is used as such stabilization mechanism allows for considerable more variation in upstream fractal grid geometry. It is shown that fractal grids provide much more intense turbulence compared to classical grids. By increasing the range of embedded scales the turbulence is intensified. The turbulence intensity can be more than quadrupled while for the turbulent flame speed more than doubling is observed.

When the standard blockage grid in a low-swirl burner is replaced by fractal grids (see Figure 1) a similar increase in turbulence and combustion rate is observed as for a V-shaped flame. Figure 2 clearly shows both these effects. The turbulence is intensified, which is expressed by more than doubling of the r.m.s. of the velocity fluctuations, while only marginal changes in pressure drop are observed. The OH-LIF experiments show an increase in flame surface density and widening of the flame brush as well as much finer wrinkling of the flame front for the cases involving a multi-scale blocking grid.

Exploded view and actual photo of a low-swirl burner with a fractal grid installed.
The fact that the range of embedded scales mainly controls the turbulence intensity and the blockage ratio the low-swirl stabilization, engineering fractal grids for low-swirl combustion can be done with relative ease. In addition to the effect on the turbulent flame speed, it has also been verified that the low NOx emission levels, a key feature of low-swirl burners, are not affected when using fractal grids.

REFERENCES