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POROUS BURNER - A New Approach to Infrared

1. Preface

There are several possibilities to produce infrared radiation in the technical sense. Regarding the source of energy you can distinguish between electrical and gas infrared burners. Electrical and gas infrared burners divide the possible fields of application according to their advantages and disadvantages. The present report treats of the application of gas infrared burners.

2. Problem

For more than 50 years gas infrared burners have been available on the market. They are used for heating purposes, for warming up, preheating and drying purposes in nearly all branches of industry.

Over the years the operating temperatures were increased. For more than 30 years the permanent operating temperatures of gas fired surface burners have been laying at approx. 1100 °C, regardless whether ceramic, metal fibres, ceramic fibres or metals are used as radiant surface. In order to reach these high temperatures premixed radiant burners were used.

On one hand the operation temperatures are limited due to the temperature resistance of the used materials. On the other hand the energy supply and thus the gas and air supply must be increased to raise the temperature at the radiant surface. This means automatically an increase of the flow velocity. The flame, burning at or in the surface of the radiant area, looses contact to the surface in case of higher flow velocity. This means the gas infrared burner becomes a gas burner with open flame.

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Principle construction shown in fig. 1

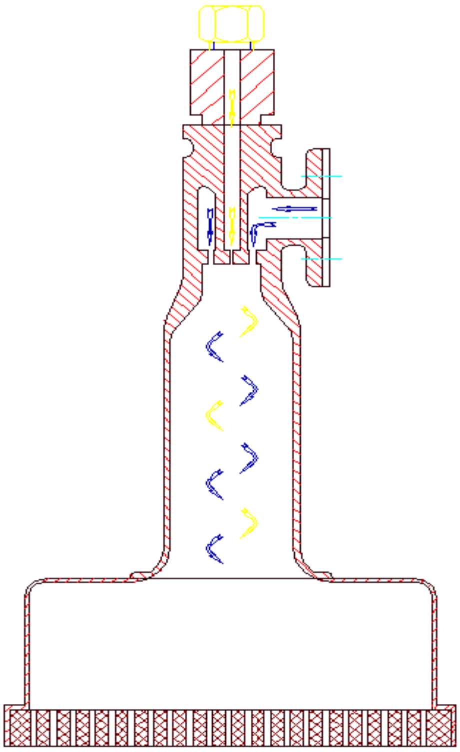

Figure 1

3. Solution

In the technology of combustion in a porous medium the combustion process does not take place in a pure gas flow as for a conventional combustion. On the contrary the combustion reaction takes place inside of an inert porous medium .With this the effective heat transport process is about a 100 times higher as for a combustion with a free burning flame.

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The principle is shown in fig. 2

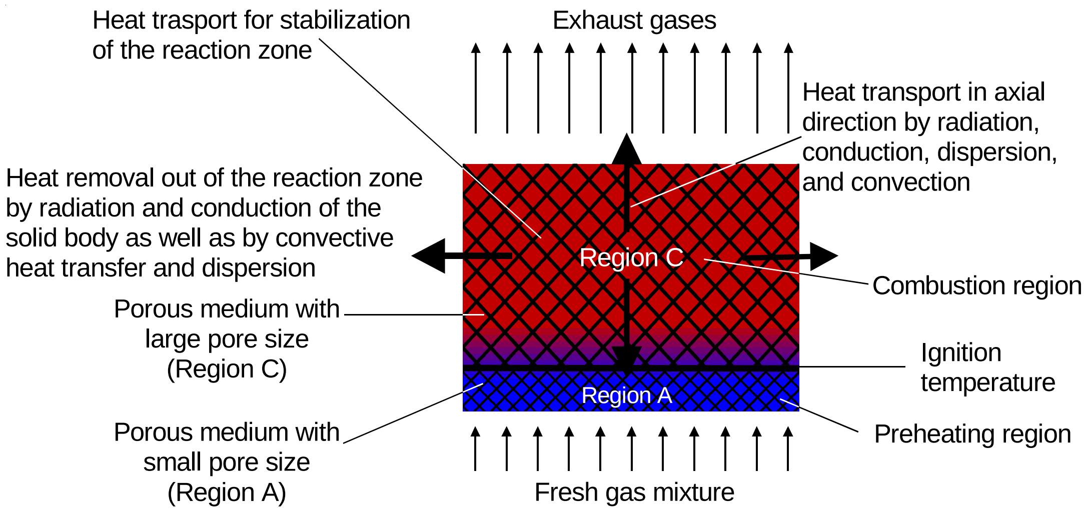

Fig. 2: Heat transport mechanism

In cooperation with the University in Erlangen, Germany, we succeeded to adapt the technology of combustion in a porous medium to a utilisation as gas infrared burner. The gas infrared porous burner RADIMAX mainly consists of the optimised porous materials as shown in figure 2. Due to the flame stabilisation inside the porous material it is possible to increase the capacity without the flame loosing contact to the radiating surface. The porous materials are located in a metallic housing. This high temperature resisting construction allows to realise an essentially higher temperature up to more than 1400 °C. Fig. 3 shows the porous burner RADIMAX in operation on a test stand.

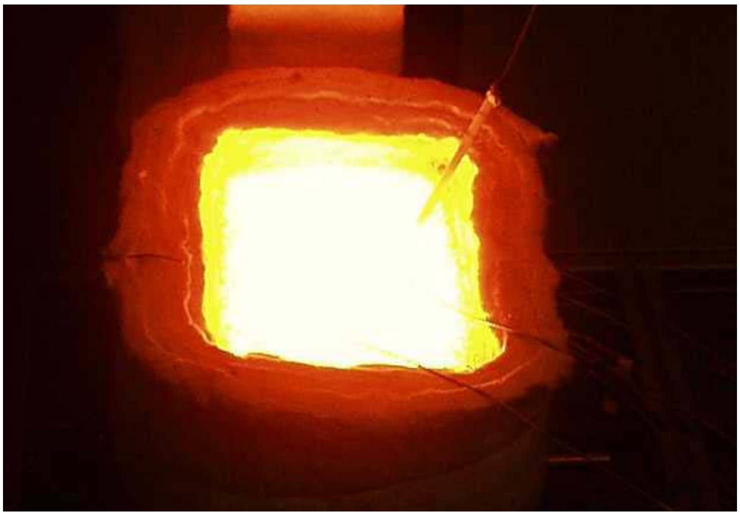

Fig. 3: Gas infrared porous burner RADIMAX in operation

4. Advantages

Theory of the infrared radiation

According to the "Planck´s radiating law" electro magnetic waves are emitted from a surface with the temperature T. According to Wien displacement law the radiation maximum moves to shorter wave-lengths the higher the temperature of the emitting surface is.

$$\lambda_{max} \cdot T = 2{,}8979 \cdot 10^{-3} \text{ [mK]}$$

λ_{max} = wave-length of maximum emission
T = temperature of the emitting surface in Kelvin

According to Boltzmann´s law the radiation emission of a black body can be described as following:

$$E = \sigma \cdot T^4$$

$$\sigma = 5{,}6697\ 10^{-8} \text{ [W/m²K4]}$$

For non black bodies the radiation emission is reduced by the grade of emission (ε<1)

$$E = \varepsilon \cdot \sigma \cdot T^4$$

Assuming that the grade of emission in the considered temperature range is independent from the temperature, the equation becomes simpler:

$$E \sim T^4$$

e.g. the emitted intensity only depends on the burner's temperature. If we equal the emitted intensity at 800 °C equal to 1 you get the following relative changes:

Temperature °C	Temperature (°K)	Relative intensitiy (1)
800	1073	1
900	1173	1,42
1000	1273	1,98
1100	1373	2,68
1400	1673	5,91

The increase in temperature from 800 °C to 1400 °C results in an approximately 6 times higher radiation emission.

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If commercial gas infrared radiant burners with a permanent operation temperature of 1100 °C are compared to the gas infrared porous burner RADIMAX the radiation emission is by 2.2 times higher at 1400 °C.

If we take the thermal surface load (installed combustion power per radiating surface) to characterise a gas IR burner, we get for the new porous burner a thermal surface load of 1000 kW/m². For comparison: the burner AK4 only has a thermal surface load of 120 kW/m².

Test results:

In order to compare the capacity of burners the following test was arranged:

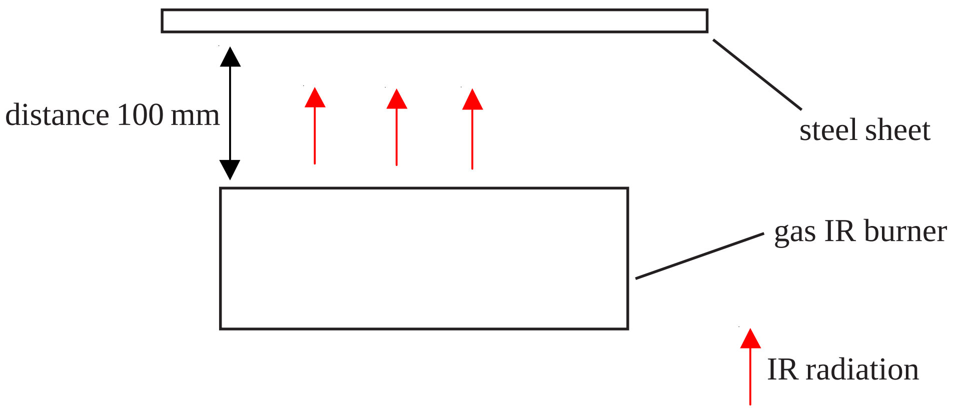

Fig. 4: Test procedure

The temperature was measured at the steel sheet. We measured a ceramic tile burner AK4 with combustion air blower (for forced air operation) as shown in fig. 1. The combustion air is pressed into the chamber. The burner is operating in a temperature range of approx. 950 °C.

Furthermore a catalytic burner was measured. This burner burns the gas in a catalytic way, i.e. the temperature is lower at about 600 °C.

The gas infrared burner RADIMAX was measured as third burner. Whereas the commercial burners reached a sheet temperature of about 100 °C within 20 sec. the porous burner RADIMAX reached a sheet temperature of 400 °C within the same time.

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Fig. 5 shows the curve diagram of the different burners.

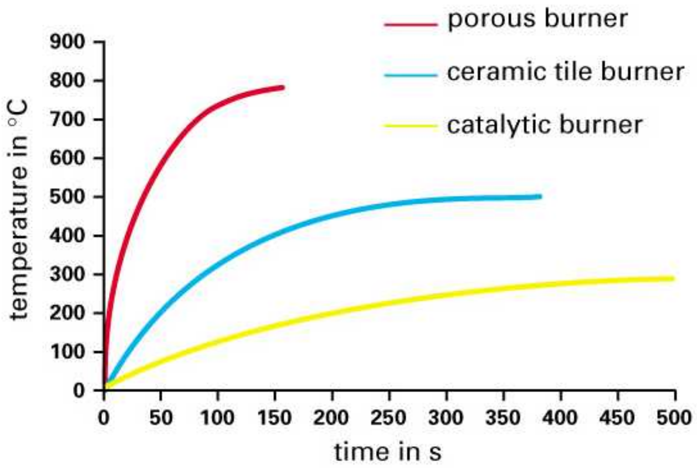

Figure 5

5. Summary

The gas infrared porous burner RADIMAX, developed in cooperation with the University in Erlangen, stands out due to an extreme high thermal surface load of 1000 kW/m² compared to the radiant burners used until now.

This is possible by using the combustion in a porous medium; a technology which stabilizes the combustion process even at high thermal surface loads inside the porous material. Due to the high radiation temperatures of more than 1400 °C completely new fields of application in the industrial drying open up.