High Energy Density for Drying of Coated Webs – Porous Burner Combustion a New Approach

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ABSTRACT

Existing gas fired burners work in the medium wave IR range at 1000 °C and an energy density of 200 kW/m². The patented porous burner technology reaches the short wave IR spectrum (1450 °C) and comes up to an energy density of 1000 kW/m². This technology is of great interest for various applications in paper industry. Speeding up existing coating lines can be realized without a major revamp of the line. Main characteristics of this new developed technology enable a better process control. In this paper the porous burner technology for paper industry is evaluated

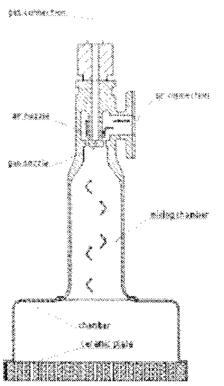
INTRODUCTION

Drying of coated webs in many applications is a combination of IR drying and convective drying. Usually the drying is limited by the configuration of the machine. In practice the drying often is the bottleneck when considering to speed up the line. These facts are valid supposed that the IR burner in operation stays at the same energy density. The porous burner combustion shows a way to get an additional degree of freedom.

THE POROUS BURNER TECHNOLOGY

The situation before porous burner technology

All existing IR-burners rely on a surface combustion, which is physically limited to approx. 1000°C and an energy density of 250 kW/m².



(Fig. 1 Principle of surface combustion burner)

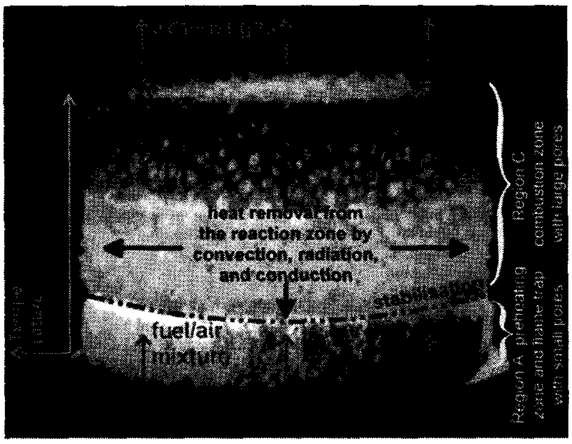
Higher temperature or higher energy density cannot be reached. The reason is that higher temperature causes higher speed and therefore higher pressure on the flame. At the end the flame looses contact to the radiating surface. Thus the heat transfer between the flame and surface is disturbed. Therefore less radiation and more convective energy is produced. (Fig1)

Porous burner technology

The porous burner technology is a completely new approach. A porous matrix is fitted in the combustion region, where the gas air mixture is combusted. Due to the porous matrix the flow of the exhaust is splitted and reunited again and again. This firstly improves the heat transfer from the flame to the solid ceramic surface decisively. The porous matrix consists of a ceramic material which has specific properties as radiation and thermal conductivity. The emissivity for all ceramics is extremely high. The thermal conductivity is 100 times higher than that of gases. These good heat transfer properties avoid any hot spots in the matrix, resulting in a homogeneous temperature profile. Because of the good heat transfer properties the power can be varied over a wide range [1].

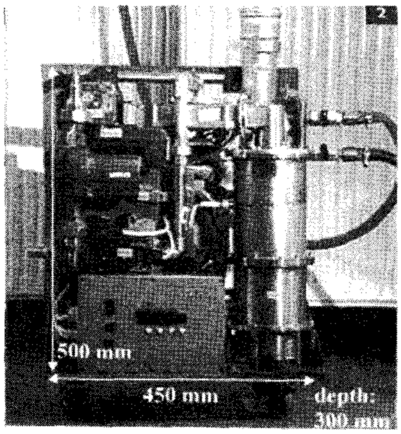
To ensure a stable combustion at all times, the burner is made up of at least two different ceramic zones. (Fig. 2)

The air gas mixture first enters in a fine pore region. This acts as a flame barrier preheating the incoming air gas mixture. In the combustion region the pore diameter is much larger (5-10 mm).



(Fig.2 Schematic diagram of the porous burner)

Because of the numerous advantages the unique porous combustion technology can be used in many different applications. For example in household appliances this technology is used as heating system, in industry you can find burners for heating systems, radiant burners for kilns, burners for steam generation and for gas turbines or solar thermal plants. [2-4]



(Fig.3 Household appliance with porous-medium burner)

Porous Burner *Radimax*

According to the „Planck's radiating law" electro magnetic waves are emitted from a surface with the temperature T. According to Wien displacement law (1) the radiation maximum moves to shorter wave lengths the higher the temperature of the emitting surface is.

$$\lambda_{max} . T = 2{,}8979 . 10\text{-}3 \text{ [mK]} \quad (1)$$

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

According to Boltzmann's law (2) the radiation emission of a black body can be described as following:

$$E = \sigma . T^4 \quad (2)$$

$$\sigma = 5{,}6697\ 10\text{-}8\ [W/m^2K^4].$$

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

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

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

$$E \sim T^4$$

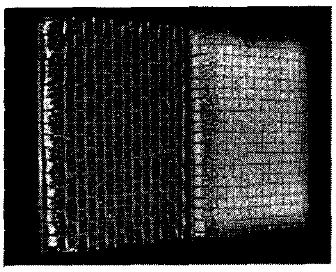
e.g. the emitted intensity only depends on the burner's temperature. If we equal the emitted intensity at 800 °C equal to 1 you get the following relative changes (Table1)

(Table 1: Relative emissivity at different surface temperatures)

Temperature	Temperature	Relative intensity
(°C)	(°K)	(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 1000 °C to 1400 °C results in an approximately 3 times higher radiation emission.

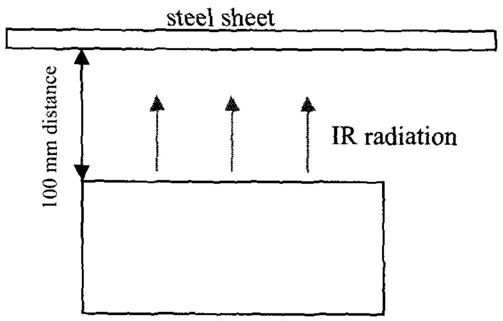
Based on the increase of the relative intensity, an infrared burner was developed. (Fig. 4)



(Fig.4 Porous burner *Radimax*)

This porous burner *Radimax* as shown is the first gas fired IR burner operating in the short wave range with a maximum of 1.7 μm wave length.

In order to compare the capacity of burners a test (Fig.5) was conducted.

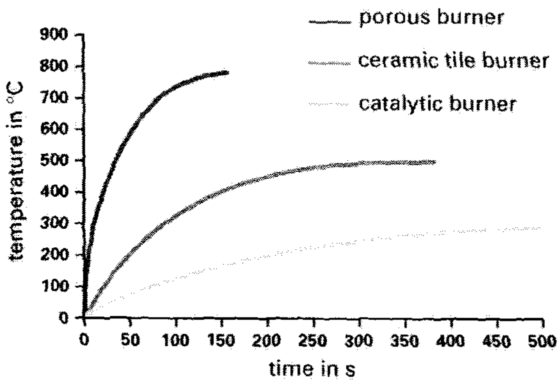


(Fig.5 Test arrangement)

The temperature was measured at the steel sheet. We measured a surface combustion burner The burner is operating in a temperature range of approx. 950 °C.

Furthermore a catalytic burner was measured. This burner combusts 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.



(Fig. 6 Test results)

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 (Fig. 6 Test results). The heat transfer to a rigid surface was dramatically increased. Using the porous combustion technology, another important fact was observed. The surface combustion can be controlled in a range between 50 and 100 % load. Setting the gas flow to less than 50 % the surface combustion burners start getting uneval distribution and therefore the combustion cannot be stabilized anymore. The porous combustion is much more inured to instability. In the tests the *Radimax* burner showed a turn down ratio of 1:6.

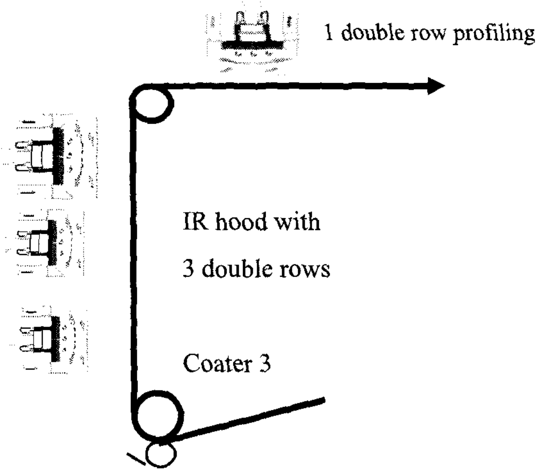
EXPERIENCES IN PAPER INDUSTRY

Test arrangement

To proof the reliability for paper industry the *Radimax* burner was tested in an existing paper machine at Stora Enso at Hagen. Technical data as you see here:

Paper weight before coater	40 – 45 gr/m²
Coat weight	40 gr/m² (4 coats)
Moisture after coater	approx. 4.5 %

In total eight rows of IR burners are installed downstream Coater 3 and row three and row four were changed from existing burners using surface combustion and installed the *Radimax* burners (Fig. 7 Principle of coater line).



(Fig.7 Principle of coater line)

Results

One row of *Radimax* can replace two rows of conventional IR burners with surface combustion. So the volume combustion of the *Radimax* is two times more intensive than existing surface combustion technology

As result of the tests it was found that *Radimax* has the same efficiency as the existing conventional burners. So this means *Radimax* does not only create a higher energy density. Heat transfer into the paper web is also accelerated, and most important without affecting the paper quality itself.

SUMMARY

Due to it's excellent properties the porous burner technology is suitable for several applications in industry.

Using the outstanding features a new IR burner for use in paper industry was developed. Compared to existing solutions the energy density was increased by a factor 3.

Comparing surface combustion with porous combustion technology the control range, in which the combustion stays stabilized, is also increased by a factor 3.

In the field the porous combustion technology proofed that the heat transfer can be doubled at same efficiency without affecting paper quality.

More long term applications are tested in paper and board industry to gain more knowledge of the long term stability of the burners.

REFERENCE

[1] Pickenäcker, O., Pickenäcker K., Wawrzinek K., Trimis D., Pritzkow W. E. C., Müller C., Goedtke P., Papenburg U., Adler J., Standke G., Heymer H., Tauscher W., Jansen F.,: Innovative Ceramic Materials for Porous-Medium Burners, Interceram, 48, 1999 [5] + [6]

[2] Durst, F., Pickenäcker K., Trimis D.: Porenbrenner – kompakte, emissionsarme Brenner mit großem Leistungsmodulationsbereich, gwf-Gas/Erdgas, 138, 1997 [2] 116-123

[3] Durst F., Kesting A., Mößbauer S., Pickenäcker K., Pickenäcker O., Trimis D.: Der Porenbrenner – Konzept, Technik und Anwendungsgebiete, Gaswärme International 46, 1997, [6] 300-307

[4] Durst F., Keppler M., Trimis D., Weclas M.: Neue Verbrennungstechnik: Der Porenbrenner in der Ölheizung. Wärmetechnik – Versorgungstechnik, 43, 1998 [1] 28-32