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Sheet Metal Surface Burner Evaluation

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Executive Summary

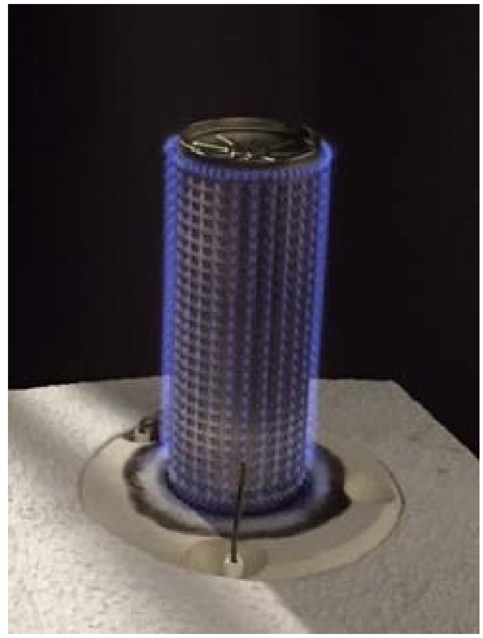

Figure 1. BLUEJET® Burner

The objective of this project is the evaluation a novel European sheet metal burner design from Sermeta based in Marlaix, France. Sermeta has been marketing and suppling this burner as the reference burner to complement their heat exchanger technology which are supplied to boiler manufacturers in Europe, Asia, and the United States. The technology is being marketed as the BLUEJET® burner and features a three-dimensional surface fabricated from a single layer of sheet metal. The formed raised features in the sheet metal reportedly provide a slight elevation of the flame above the service. The result of this elevation has been described as allowing improved flame stability, very high turndown ratios, and performance at low and high firing rates. Figure 1 shows the operation of the burner in the GTI burner development laboratory. The goal is to substantiate these performance claims in the current US Boiler product and to identify possible paths to drive the emissions below 5 ppm across the operating range.

The burner tested during this project is currently being utilized for high efficiency small boilers, the technology may have other larger industrial/commercial applications if scaled in capacity. The primary target most likely would be small diameter combustion chambers applications.

To complete the evaluation of this burner technology GTI completed the following tasks:

- Procured a US Boiler K2 model condensing boiler utilizing the Sermeta BLUEJET® burner
- Build a test cell for operating of the boiler and performance testing of the burner
- Completed testing characterizing the burner performance compared to the Sermeta an US Boiler product stated burner attributes
- Completed burner operation with increase excess air and flue gas for evaluation of NOx reduction.

The results of the evaluation completed substantiated the performance claims of this burner technology, and can support enhancements to utility energy efficiency and emission-reduction programs. The burner demonstrated a high modulation ratio with outstanding flame retention performance. Testing confirmed that a 40:1 modulation ratio operation of this burner design is possible. The burner emissions compared favorably to the current low NOx emission surface combustion burner technology commercially available, but above those provided by US Boiler during initial discussions. GTI conducted the testing with the boiler operating at a heating load simulating actual operation in a typical heating application. The measured NOx emission would be lower during test condition in which the inlet water to unit is kept well below the condensing range of the equipment which is typically used in standard efficiency rating testing.

The project also evaluated two possible paths to drive the NOx emissions below 5 ppm across the operating range. These paths were to increase the excess air to the burner and adding flue gas recirculation. The test results indicate that both methods are effective in reduction of the NOx emissions. Increasing the excess air above 8% oxygen was able to achieve the project goal of below 5 ppm. The external flue gas recirculation approach also provided effective NOx reduction and at the highest rate tested of 25% came close to matching the 5 ppm NOx objective.

The GTI experience in working with the Sermeta burner and heat exchanger technology, which are both utilized in the US Boiler K2 used on this project has overall been positive. Both have provided performance as indicated in both the information from Sermeta and US Boiler. During this project the burner and heat exchanger technology has been scaled up by Sermeta and is being marketed as NHEXT® (New Heat EXchanger Technology). The target for this technology is industrial heating and hot water applications with outputs up to six million btu. The heat exchanger is configured to allow a four-pass recovery from the flue gas with reported maximum thermal efficiency of 97.5% across the operating range. In addition, the design allows for significant size and weight reduction compared to other condensing technologies at this output size range. Bluejet® burner is used in this design with a rated modulation ratio of 30 to 1 which, depending on the application could result in reduction numbers of ignition cycles required for variable demand applications.

The project results present a solid basis for continuation of this work in a field deployment and demostration with the scaled-up version of the technology. Given the high performance of the technology and the straightforward, low-cost design, it would be able to offer a very competitive product to the industrial market, ultimately driving broad deployment resulting in increased operating efficiency with lower emissions to the end user. It is the recommendation of this report that this technology move towards field industrial application demostration. There will be several issues that will need to be overcome. The main issue would be that Sermeta is presently only supplier of the heat exchanger technology to boiler manufacturers. Until the NHEXT® technology is utilized by a domestic boiler manufacture obtaining a boiler for a demostration may present a challenge moving field demostration forward quickly. GTI is currently engaged with Sermeta and has proposed development of field demostration in the North American market of the NHEXT® technology in an industrial or large commercial application.

Introduction

The development of surface combustion gas burners has taken the form of two widespread types. The first type includes a combustion grid fabricated from a metal or ceramic sheet perforated with small holes of varying size. Typically, these designs produce only a 3:1 modulation ratio. The second burner type adds a metal fiber mat to the perforated metal sheet as a flame holder (for increased modulation performance) and a thermal insulator (to reduce the temperature of the metal sheet support). The use of the metal fiber mat results in modulation ratios in the range of 5:1, with up to 10:1 achievable. The addition of the metal fiber layer increases the cost of the burner significantly and requires periodic replacement due to degradation over time. In this project, a novel European sheet metal surface combustion burner was evaluated. The manufacturer claims that the burner is:

- Lower cost, less than current metal fiber burner designs
- Has a high modulation ratio (40:1) with high flame-retention performance while maintaining the flame above the burner surface for increased burner lifetime, and
- Provides a reduction in emissions (up to 50%) compared to currently widespread employed surface combustion burner technology.

Effective use of low-cost formed sheet metal components without the additional aid of metal fiber coating could provide a path for high performance lower-cost burner designs with improved lifetimes.

Motivation and Background

Advanced low-cost burner designs are essential for the continued development of a wide range of commercial and industrial gas fired equipment for applications such as fluid or material heating. The use of low cost formed sheet metal components without the additional aid of metal fiber coating could provide a path for lower cost burner designs with improved lifetimes before replacement.

High-performance, low-cost burners are a key component of next-generation, natural gas-fired equipment both in the commercial and industrial marketplace. The market continues to demand increased efficiency and lower emission targets into the foreseeable future. In order to meet these expectations along with the goal to enable increased use of natural gas through efficient utilization of energy delivered to the end user requires development of low-cost burner designs with increasing output modulation capabilities.

Increases to the output modulation of available burner technology will improve efficiencies by:

- Enabling a wider burner operating range to better follow actual heating load
- Reduce cycling through burner shutdown and restart, thus eliminating reheating losses
- Allow use of advanced control technology (e.g. auto-adaptive controls)
- Enable continued progress in design of new gas fired equipment with improved energy efficiency and performance.

Development and use of higher turndown natural gas-fired burner designs provides a path for increased development of efficient and higher performance natural gas equipment. Utilization of advanced burner controls coupled to high turndown burners provide improved load matching resulting in increased efficiency and reduced emissions. In order to maximize the benefit of advance control technology burners with increased modulation rates compared to those currently available, lower cost burner designs are needed. Performance improvements will provide end users with more choices of efficient products.

Approach

During this project the performance claims were validated of this surface burner technology through design and develop a test cell for evaluation and verification of actual operating performance. This was accomplished by procurement of a production model of a US Boiler K2 model water tube boiler utilizing the Sermeta designed BLUEJET® burner. GTI designed and develop a test cell utilizing this boiler without and with modifications to the operation of the boiler evaluation and verification of burner operating performance.

GTI developed and implement a test plan to accurately assess the burner performance including evaluation of the modulation ratio, sheet metal temperature, and emissions. During testing GTI first validated initial burner performance in the US Boiler product and emissions at high, medium and low firing rates, and then identify and test possible paths to drive the emissions below 5 ppm across the operating range.

To complete this evaluation GTI planned the following tasks:

- Procured a US Boiler K2 model condensing boiler utilizing the Sermeta BLUEJET® burner
- Build a test cell for operating of the boiler and performance testing of the burner
- Completed testing characterizing the burner performance compared to the Sermeta an US Boiler product stated burner attributes
- Completed burner operation with increase excess air and flue gas recirculation for evaluation of NOx reduction.

Objective

This project evaluated a novel European technology for a sheet metal surface combustion burner design undergoing introduction to the commercial condensing boiler markets in the United States. The burner technology which is the object of this project is the BLUEJET® burner by Sermeta of France. This burner technology, which claims up to a 40:1 modulation rate and with a three-dimensional surface for improvement of the flame stability and performance. These raised surface features are claimed to provide the improved burner performance with a benefit of a reduction in emissions of NOx and reduced metal surface temperature by a slight elevation of the flame above the burner surface. The objective of this laboratory evaluation is to substantiate these performance claims of this surface burner technology in the current US Boiler product and to also identify and test possible paths to drive the emissions below 5 ppm across the operating range.

Project Goals

Upon completion of this laboratory evaluation and testing, the objective will be to engage US Boiler and/or Sermeta to collaborate with UTD in subsequent product-focused development and technology demonstrations of the technology within the industrial and large commercial application market. A burner that can provide a high modulation ratio with flame stability and performance can provide the versatility necessary for increases to equipment operational efficiency. While the burner as designed and tested under this project is being utilized for small high efficiency boiler applications it would also have multiple other applications once scaled up to larger firing rates, the primary target would most likely be small diameter combustion chambers applications.

Laboratory Burner Performance Evaluation

GTI designed and constructed a functional boiler test cell and installed it in the GTI Boiler Laboratory. This test cell provided the necessary utilities and heat load control for operation of the US Boiler K2 boiler used on this project for evaluation of the burner performance. The piping configuration of this test cell and support utilities is presented in Figure 2 and the completed test cells as installed in the GTI Boiler Laboratory is shown in Figure 3. This test cell was the primary test configuration utilized for both baseline performance evaluation and identification and testing of possible paths to drive the emissions below 5 ppm across the operating range of the burner design.

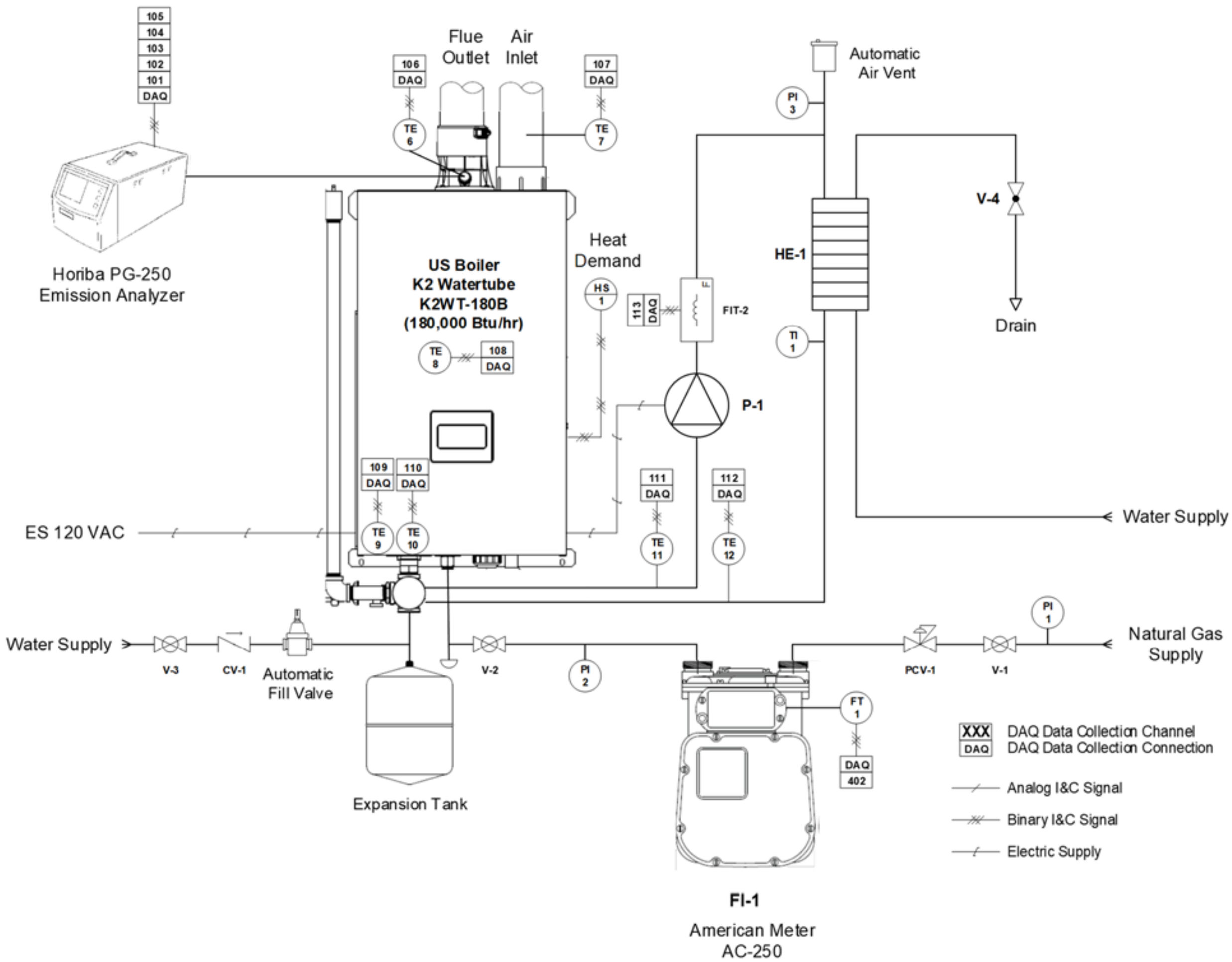

Figure 2. Laboratory Test Set Up

Figure 3. Laboratory Test Cell

Direct Measured Values

In order to quantify the performance of the burner relative to the project objectives, multiple direct measurements needed to be made. These direct measurements were used, if required to calculate the other values of interest and reported in the results section of this report.

Direct measurements of the following parameters obtained using standard GTI laboratory instrumentation:

- NOx Concentration (dry)
- CO Concentration (dry)
- CO_2 Concentration (dry)
- O_2 Concentration (dry)
- Fuel Flow Rate
- Flue Sample Temperature
- Burner Sheet Metal Temperature(s)

The burner flue gas composition measurements for this project were made according to the standard industrial methodologies by a Horiba PG-250 portable emission analyzer. In general, the gas sampling methodology adhered to the following practices.

- Flue gas sampling location sufficiently close to burner or boiler flue outlet
- Moisture removed from flue gas sample as recommended by the instrument manufacturer
- Calibrated gas analysis equipment, with calibration gases of appropriate range and accuracy

The fuel flow rate measurements were acquired at the inlet of the either the bench mounted burner through a Brooks 5850E mass flow meter or at the inlet of the US Boiler product through an American Meter AC-250 diaphragm gas meter.

The flue gas temperature and burner sheet metal temperature(s) were measured using standard Type K thermocouples. The flue temperature measured and reported were made at the same location as the flue gas sample measurement.

To facilitate evaluation of the burner performance, the measured data was be used to calculate meaningful variables of interest as indicated in the calculated values section of this report.

Calculated Values

NOx

The dry direct NOx concentration measurement and dry direct O_2 concentration measurement will be used to calculate the dry NOx concentration on a 3% O_2 basis using the following equation.

$$\mathbf{NOx}_{(\text{at } 3\% \text{ O2})} = \boldsymbol{NOx}_{(raw)}\left(\frac{\mathbf{20.9 - 3}}{\mathbf{20.9 - O2}_{(\text{raw})}}\right) \quad \mathbf{(1)}$$

CO

The dry direct CO concentration measurement and dry direct O_2 concentration measurement will be used to calculate the dry CO concentration on a 3% O_2 basis using the following equation.

$$\mathbf{CO}_{(\text{at } 3\% \text{ O2})} = \boldsymbol{CO}_{(raw)}\left(\frac{\mathbf{20.9 - 3}}{\mathbf{20.9 - O2}_{(\text{raw})}}\right) \quad \mathbf{(2)}$$

O_2

The raw measurement of the dry O_2 concentration directly correlates to the excess O_2 level. No calculation is required.

Turndown

The turndown of the system will be characterized by evaluating the flow rate of natural gas to the burner at high and low fires. The turndown will be calculated as the ratio of the gas flow rate measured at high fire divided by the gas flow rate measured at low fire.

Flue Gas Recycle Rate

The flue gas recycle rate will be calculated as the volume percentage of flue gases in the combustion air/flue gas going to the burner at each firing rate.

Assumptions/Constrains

1. Baseline emission testing performance evaluation was limited to within the rated capacity of the available in the US Boiler K2 Boiler product.
2. Bench testing of the burner test configuration was limited to within the capacities of the gas mixing instrumentation and safe venting of exhaust gases. This testing was primarily to allow visual observation of the burner flame and evaluation of firing rates below those available in the US Boiler K2 Boiler operation.

Baseline Performance Testing

An initial baseline evaluation of the burner performance was conducted to determine the typical operating burner performance in the commercially produced boiler product. The boiler was operated across the designed firing rates by manual adjustment of the heat load while emissions and other key operating parameters were measured and recorded. Each firing rate was held for a minimum of fifteen minutes after reaching steady state temperature conditions. The average burner combustion measurements at each firing rate are presented in Table 1. The results showed that the during this testing the burner was operating between 4 to 5% excess oxygen across the operating range of the boiler. The highest NOx emission levels are experienced at the middle of the firing range, which correspond to the lower excess oxygen feed to the burner in this range. GTI did not adjust the fuel/air controls as they met the manufactures recommend adjustment targets at high and low firing rates prior to testing. Measurement obtained of the burner surface temperatures are presented in Figure 3.

Table 1. Baseline Summary

Baseline Testing Summary										
Firing Rate		**Emissions (dry)**				**Temperature**		**Emissions (dry) Corr 3% O_2**		
Nat Gas (scfm)	H_{in} (btu/hr)	NOx (vppm)	CO (vppm)	CO_2 (%)	O_2 (%)	Vent (F)	Inlet (F)	NOx (vppm)	CO (vppm)	CO_2 (%)
0.34	21,459	9.5	0	9.1	4.76	167.7	78.4	10.6	0	10.1
0.55	34,453	11.6	0	8.8	5.32	168.0	79.2	13.3	0	10.1
1.34	84,587	38.1	42.1	9.5	4.05	139.2	79.6	40.5	44.8	10.1
1.93	121,275	28.6	77.7	9.3	4.29	139.3	80.5	30.8	83.8	10.0
2.68	169,145	24.4	123.0	9.1	4.55	134.5	81.2	26.5	133.3	10.0

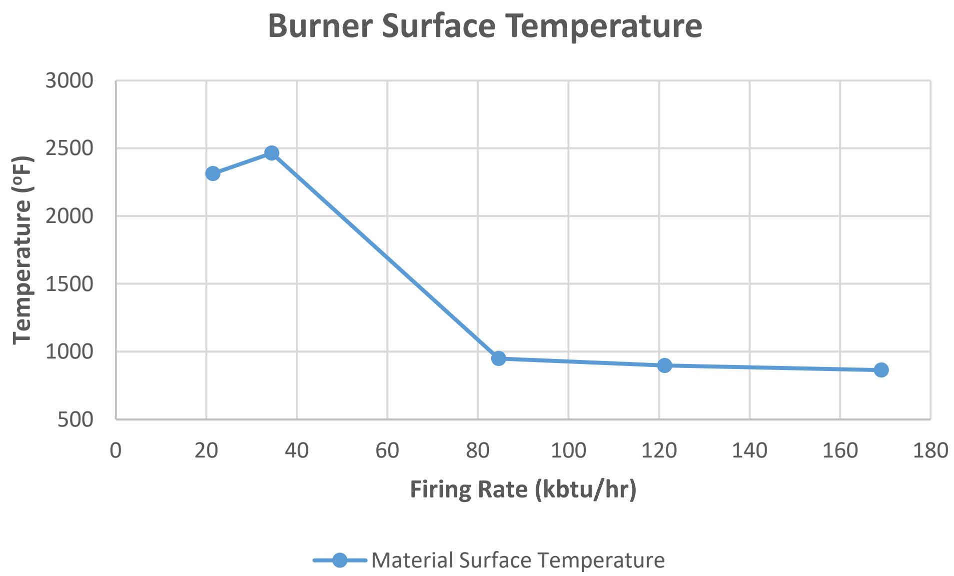

Figure 4. Burner Surface Temperature

To permit improved visual observation and testing of flow rates below those allowed by the operation in the US Boiler product a burner assembly was also installed the small GTI burner development area. This test area provides more flexible fuel and air metering instrumentation and control for limited firing rates of burners on an open test bench. The advantage to this approach it allows for improved visual observation of the burner operation at very low firing rates without containment within a combustion chamber of a heat exchanger. A quartz tube is installed around the burner and is used to restrict the burner from surrounding air during testing. The test bench is covered with a ventilation hood for handing the burner flue gases for safe operation of the open burner and is typically used by GTI for development of in-house prototype burner design and development activities. Figure 5 presents the burner assembly used during evaluation during this project being operated on the open test bench.

Figure 5. Burner Bench Testing

The main objective of testing in the burner development area was the ability of operate the burner at flow rates lower than the K2 boiler controls would allow to quantify the minimum stable flame firing rate that could be achieved with this burner. The burner assembly was operated at flow rates varying from 4.4 kbtu/hr to 17.8 kbtu/hr representing 9.7:1 to 40.9:1 modulation ratio based upon the rated maximum burner output of 180 kbtu/hr of the K2 boiler. During testing the burner was operated surrounded by a six-inch diameter quartz tube act as a combustion chamber air boundary for the burner. A stable flame was observed throughout testing during operation at the low flowrates. Figure 6 shows the burner operating at the 4.4 kbtu/hr firing rate and represents the lowest stable combustion rate produced during this project.

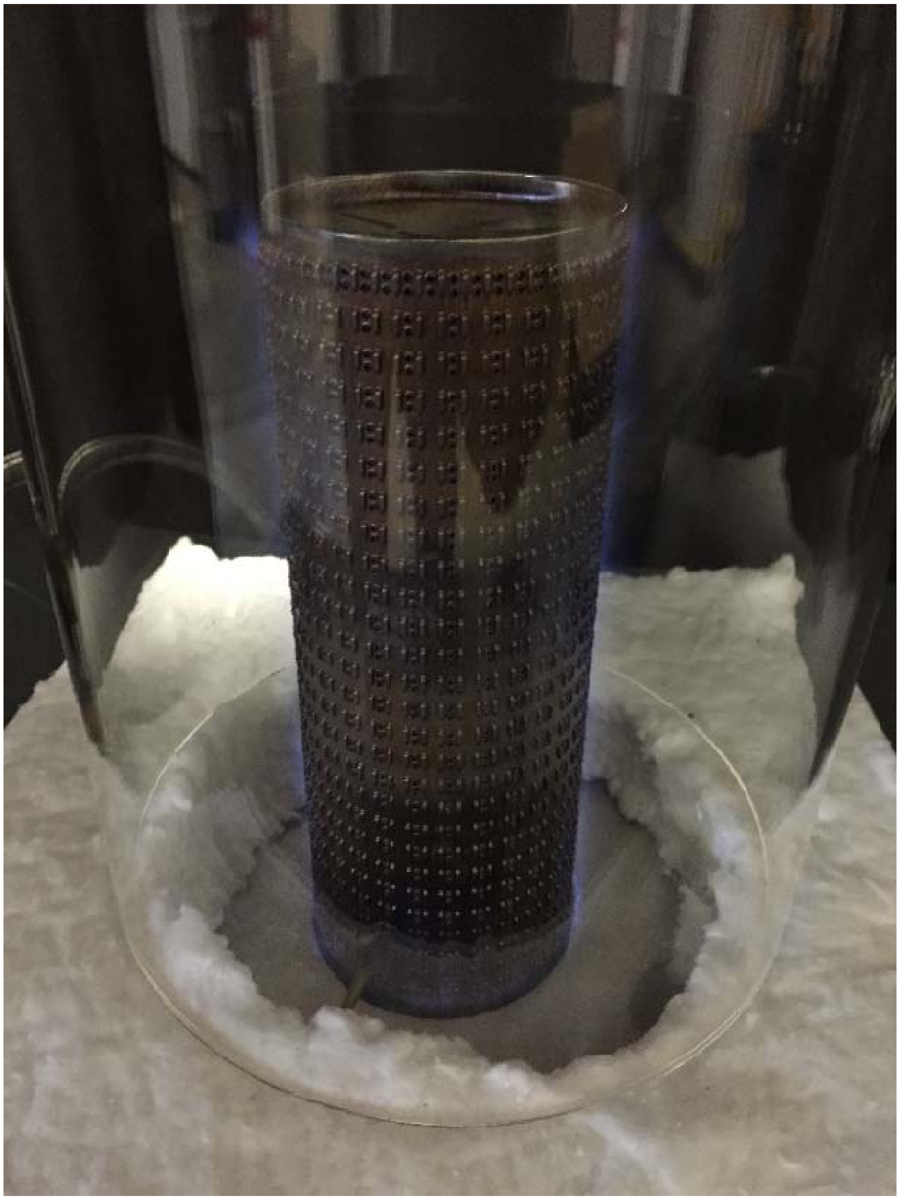

Figure 6. Lowest Burner Firing Rate

Paths to Lower NOx Emissions

The formation of NOx during combustion of fuels and oxidants containing nitrogen and oxygen is of increasing environmental concern and due to increasing stringent governmental regulation. Several variables influence the formation of NOx during the combustion process including:

- Flame temperature
- Air temperature
- Operating temperature
- Chemical reactions and rates within the flame

Of these variables the flame temperature has the most influence in the rate of NOx formation. The air and equipment operating temperature are also related to the flame temperature and as a result also can have an influence on NOx formation. There are a range of general approaches that have been identified currently for reduction of NOx formation during the combustion process:

- Burner design, such as staged combustion to reduce flame temperature
- Adjustment of the excess air
- Flue gas recirculation
- Chemical additives (ammonia)
- Catalytic reduction

The first three approaches address prevention of NOx formation by reduction of flame temperature. The last two approaches listed above are a post-combustion approaches which allows the NOx to form then breaks the NOx emissions into other constituents in the flue gases before they are exhausted. These are normally utilized to larger utility sized equipment because of the system complexity and operating requirements.

The burner used for this project is a simple single sheet metal design. As such modification of the burner design to include a staged combustion approach could not be accomplished within the scope of this project. This left two approaches to NOx reduction for evaluation, adjustment of excess air and flue gas recirculation. Both approaches for NOx control have some practical limitations which would have to be carefully balanced to consider them as a desirable solution. Both work by suppression of the flame temperature which has a negative impact on thermal transfer performance of the system and thus will reduce efficiency.

Excess Air Testing

The initial "baseline" evaluation of the burner performance was conducted first to determine the typical operating burner performance in the commercially produced US Boiler K2 product. The boiler tested is based upon use of the Sermeta BLUEJET® burner and an Isothermic® model heat exchanger. This heat exchanger is based on Sermeta's hydroformed tube technology which is shown in Figure 7. The burner is supplied by an air-gas-ratio control assembly from epm-papst which combines the air blower, gas valve, and ratio control in one assembly. This unit as limited adjustment for controlling the excess air that would be needed for our testing purposes.

Figure 7. Sermeta Isothermic Heat Exchanger

To provide the necessary regulation of the combustion gas composition being supplied the burner for testing the burner performance for both, excess air and flue gas recycle it was determined that modification to the boiler was necessary. The burner assembly was removed from the boiler and a supplemental gas supply tube was welded into the manifold supply to the burner. A picture of the tube is shown in Figure 8. During testing metered air was supplied through this tube to achieve the desired excess air flow to the burner.

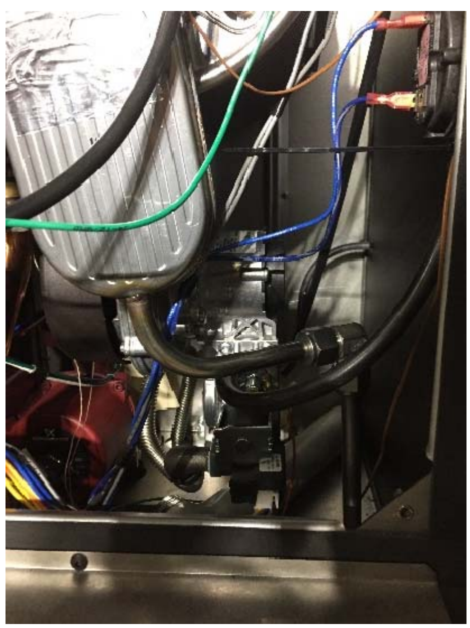

Figure 8. Supplemental Supply Tube

The boiler was operated at multiple excess oxygen rates and firing rates by adjustment of the heat load with additional metered air flow through the supplemental supply tube while emissions and other key operating parameters were measured and recorded. Each firing rate was held for fifteen minutes after reaching steady state temperature conditions. The summary of the average NOx measurements at each firing rate and excess oxygen test point are presented in the Figure 9. The results show that the during this testing the burner produced the highest NOx emission levels at the middle of the firing range, a similar pattern was found during baseline testing. As can be observed operation of the burner at 8% excess oxygen would be required to meet the project goal of NOx emission below 5 ppm across the burner operating range. This would result in a 2.5% reduction in efficiency due to the reduced flame temperatures and increased air flow through the burner.

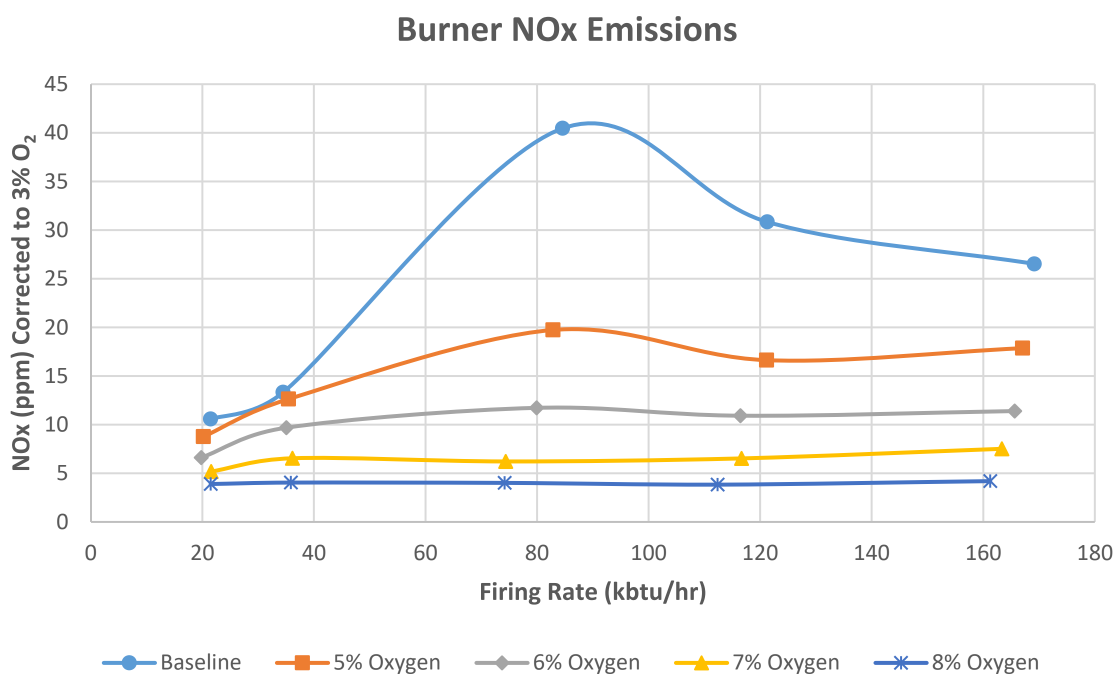

Figure 9. NOx Emissions with Excess Air

Flue Gas Recirculation Testing

The most direct method for implementation of flue gas recirculation is to draw the flue gases out of the flue exhaust duct and blend them with the combustion gases supplying the burner. This technique is common and has been applied in the past to burners without further modifications. Although this method has practical advantages if also has a drawback of a reduction in burner capacity due to the increased flow rates involved. Since our test boiler was a condensing type the flue gas temperatures were low enough that a high temperature blower was not needed. The modifications to the boiler were limited the additional manifold supply tube was utilized during the excess air testing along with a small vortex blower controlled by a variable motor drive which was connected to the exhaust stack. A picture of the test set up used for testing is presented in Figure 10.

Figure 10. Flue Gas Recycle Test Set-Up

The boiler was operated at multiple flue gas recycle rates by adjustment of the blower speed through the blower variable speed control. The emissions and other key operating parameters were measured and recorded. Each firing rate and flue recycle rate was held for a minimum of fifteen minutes after reaching steady state temperature conditions. The summary of the average NOx measurements at each firing rate and flue recycle rate test point are presented in the Figure 11. The results show that the recirculation of the flue gas was quite effective in the reduction of NOx emission levels even at the lowest recycle rate. As can be observed even operation at the highest recycle rate the burner tolerated would come close but not meet the project goal of NOx emission below 5 ppm across the burner operating range. There is not currently an accepted standard for calculation of percentage of flue gas recycle rate. The percentage of total flue gas that is routed back to the burner is used sometimes. For this testing conducted, GTI used the percentage of flue gases in the combustion air/flue gas going to the burner. This approach was used as the flue gas injected into the supplied combustion air by the fuel-air controller through the supplemental supply tube could be measured directly.

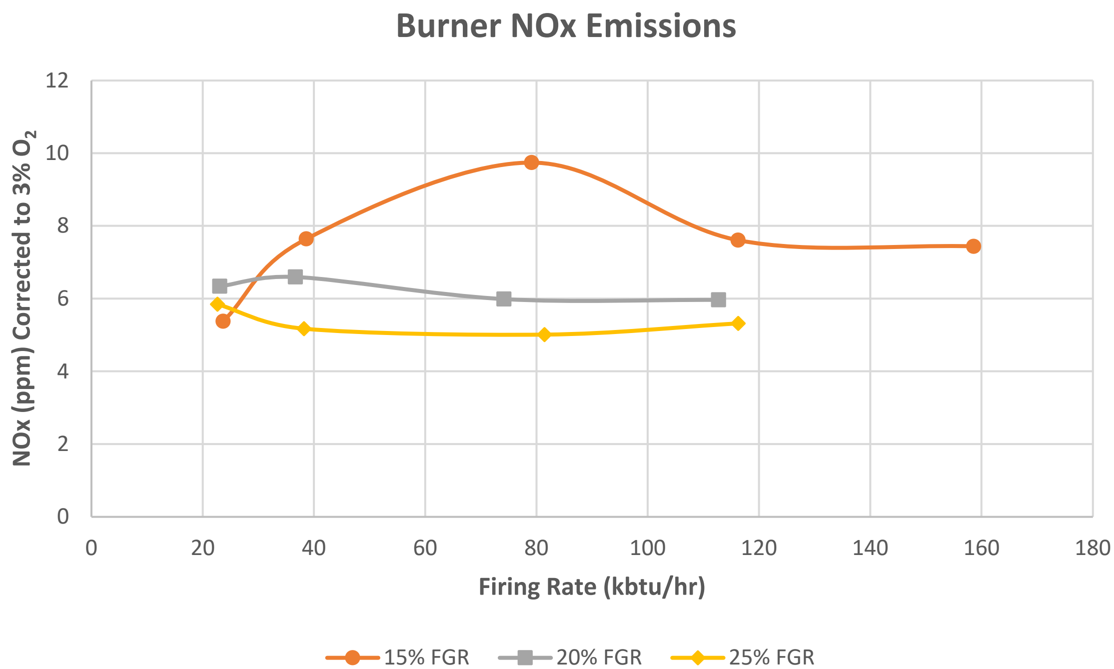

Figure 11. NOx Emission with Flue Gas Recycle

Summary of Results

The results of the laboratory testing substantiated the majority of the performance claims of this burner technology. Through the testing conducted the burner demonstrated a high modulation ratio with outstanding flame stability and retention performance. Testing confirmed that a 40:1 modulation operation of this burner design is possible. Burner emissions during testing compared favorably to the current low NOx emission surface combustion burner technology commercially available, but above those provided by US Boiler during initial verbal discussions. GTI conducted the testing with the boiler operating a heating load simulating operation in a typical heating application. One could expect that the measured NOx emission would be lower depending on the temperature of the heat exchanger surrounding the burner which would aid in lower the flame temperature. This would be expected for typical testing conditions for testing condensing heating equipment in which the inlet water to unit is kept well within the condensing range of the equipment.

Two approaches were identified and implemented during testing for possible paths to drive the NOx emissions below 5 ppm across the operating range. These approaches were the adjustment of excess air and flue gas recirculation. The results indicate that both methods are effective in reduction of the NOx emissions during operation of this burner. Increasing the excess air was able to achieve the project goal of below 5 ppm if increased to 8% oxygen, which is approximately double the baseline operating value. The external flue gas recirculation approach also provided effective NOx reduction and at the highest rate tested of 25% came close to matching the 5 ppm NOx objective. A summary of test data is presented in Figure 12 which shows the average NOx emission across the burner firing range for each operating mode tested.

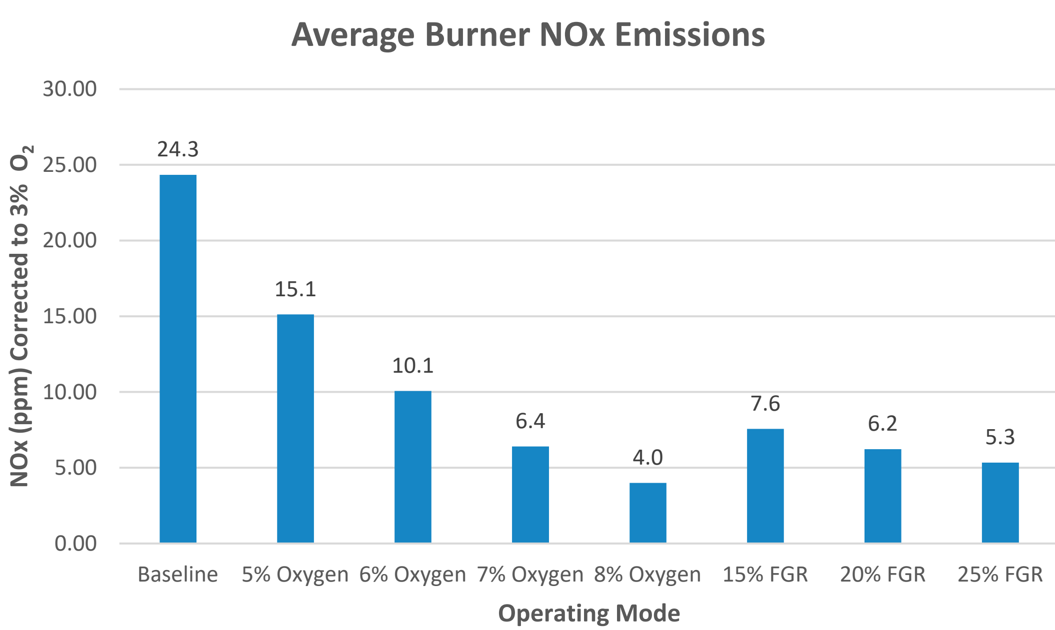

Figure 12. Summary of NOx Emissions

Target Market Assessment

The burner's manufacturer Sermeta was started in 1993 by Joseph Le Mer based upon its development of simple hydroformed stainless steel heat exchangers for condensing boilers. Sermeta has since progressed to size to supplying over two million heat exchangers each year boiler manufactures throughout Europe, Asia, and the United States. The Bluejet® burner was developed as the reference burner for use on Sermeta heat exchangers due to its modulation capacity and flame retention performance.

Currently Sermeta appears to be attempting to enter the industrial hot water market utilizing a scaled-up version of both the burner and the heat exchanger technology it has developed over the years. This new industrial scale offering is called NHEXT® (New Heat EXchanger Technology). The target for this technology is industrial heating and hot water applications with outputs up to six million btu. The heat exchanger is configured to allow a four-pass recovery from the flue gas with a maximum of 97.5% thermal efficiency across the operating range. The heat exchanger design allows for size and weight reduction compared to other condensing technologies at this output size range. Bluejet® burner is used in this design to provide turn down ratio of 30 to 1 which results in large reduction numbers of ignition cycles. A summary of this new product line is presented in Figure 13.

Figure 13. NHEXT Heat Exchangers

The small size and weight of these heat exchangers combined with the high thermal efficiency across its operating range should make them alternative to be considered for many industrial or large commercial applications.

The need for increased energy efficiency and greenhouse gas emissions reduction in industrial and commercial sectors will positively influence the market. Natural gas equipment that can meet increased regulatory constraints and still meet a diverse range of needs will be of the most value to end users in the future. The introduction of more rigorous regulatory reforms toward the minimization of greenhouse gas emissions will accelerate the drive for larger packaged condensing boiler in the industrial and commercial markets. The gas fired commercial boiler market alone is projected to grow over 3% by 2024. The lower operation cost of gas fired equipment, combined with lower emissions and increased efficiency will propel the product adoption.

Conclusions and Recommendations

This evaluation of this burner technology demonstrated that it may be operated successfully with up to 40:1 turndown ratio, validating the high modulation ratio with outstanding flame retention performance, and supporting potential enhancements to utility energy efficiency and emission-reduction programs. Emissions from burner operation during testing compared favorably to the current low NOx surface combustion burner technology commercially in use today. The burner as currently designed responded well when operated utilizing common methods of NOx reduction and was able to provide stable combustion through the testing conducted. Both these methods involve substantial increases in combustion gas flow rates through the burner. The burner was able to achieve the project goal of below 5 ppm NOx if excess oxygen is to 8% and came near to the goal with a flue gas recycle rate of 25%. The impact of this reduction in NOx utilizing either method though would present a slight negative impact efficiency due to the increased oxidant flow rates and lower flame temperatures.

The burner is based upon a unique design that feature a combustion grate consisting of a single piece metal sheet comprising a series of perforated holes and shielded slots protruding on the surface. It is this pattern formed of holes and slots that allow the burner to operate at very high firing rates without separation of the flame, and conversely at very low firing rates without flashback by elevation the flame above the surface of the burner. Figure 14 is an illustration showing the approach utilized by the burner in principle for holding the flame on the surface of the burner surface, and Figure 15 is a photograph of the burner showing the fabricated sheet metal surface projection features.

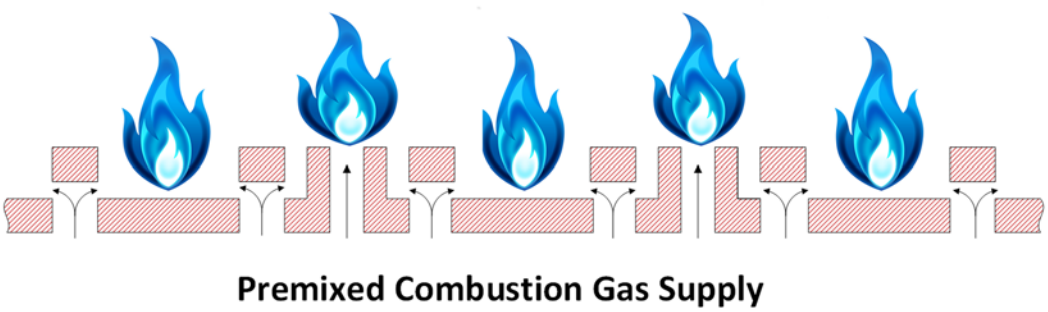

Figure 14. Cross Section of Burner Surface

Figure 15. Burner Combustion Surface

Over the course of this project GTI has been able to become familiar with the basic Sermeta burner and heat exchanger technology, which are both utilized in the US Boiler K2 used on this project. These have worked very well together during our testing and were able to provide performance as indicated in the information published by Sermeta and US Boiler. The results of this project provide a firm technical support and a solid basis for continuation of this evaluation of this technology in a field deployment and demostration on a larger scale. During this project, as summarized in the Target Market Assessment section of this report, the burner and heat exchanger technology has been scaled up by Sermeta significantly for use in industrial hot water and heating applications. It is the recommendation of this report that evaluation of this technology be continued through an industrial application field demostration. Given the high performance of the technology and the straightforward, low-cost design, Sermeta should be able to offer a very competitive product to the industrial and large commerical market, ultimately driving broad deployment resulting in increased operating efficiency with lower emissions to the end user.

There will be several issues that will need to be overcome to putting together a field demostration of this technology. The main question would be that Sermeta is presently only supplier of the heat exchanger technology to boiler manufacturers. Until the NHEXT® technology is utilized by a domestic boiler manufacturer obtaining a boiler for a demostration may present a challenge to moving a field demostration forward quickly. GTI is currently engaged with Sermeta and has proposed development of laboratory evaluation progressing to field demostration in the North American market of the NHEXT® technology in an industrial or large commercial application.

References

Patents and Patent Applications

"Surface Combustion Gas Burner," Joseph Le Mer, U.S. Patent Application No. 14/412,277, July 3, 2014.

"Heat Exchanger," Joseph Le Mer, U.S. Patent Application No. 15/881,607, January 26, 2018

Papers and Presentations

"BTS-2000 Testing Standard, Method to Determine Efficiency of Commercial Heating Boilers," The Hydronics Institute Division of AHRI, revises the January 2001 edition to be consistent with the U.S. Department of Energy efficiency test procedures for commercial boilers

"Flue Gas Recirculation for NOx Reduction, Eclipse Combustion Inc., SP-417

Tom Costello and Armin Hauer of ebm-papst, Inc., "New Generation of Premix Gas Blowers" presented at the 51st Annual International Appliance Technical Conference, Lexington, KY (May 2000)

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Bobby Gunter of Bekaert, "Premix Burners and Applications", presented at the American Society of Gas Engineers ASGE National Conference, June 4-5, 2018

Tom Costello of ebm-papst, Inc., "Gas-air-ratio Technologies for High Efficiency Gas Fired Appliances", presented at the American Society of Gas Engineers ASGE National Conference, June 2-3, 2014

List of Acronyms

Acronym	Description
btu	British Thermal Unit(s)
CO_2	Carbon Dioxide
CO	Carbon Monoxide
FGR	Flue Gas Recirculation
GTI	Gas Technology Institute
NOx	Nitrogen Oxides
O_2	Oxygen
ppm	Parts Per Million
vppm	Volumetric Parts Per Million

Appendices

US Boiler K2 Product Data Sheets

K2

It's the condensing boiler that you've been asking for…

Contractors told us exactly what they wanted. A value-priced, high efficiency condensing boiler that is simple enough to install quickly AND offers valuable extras not found on competitive models. U.S. Boiler Company has delivered.
The K2 offers a comprehensive feature list, unequalled ease of setup, maintenance, and operation in a package that costs far less than you'd expect for the impressive value that's built in. And best of all, it's built and tested with pride in Lancaster, Pennsylvania by U.S. Boiler Company.

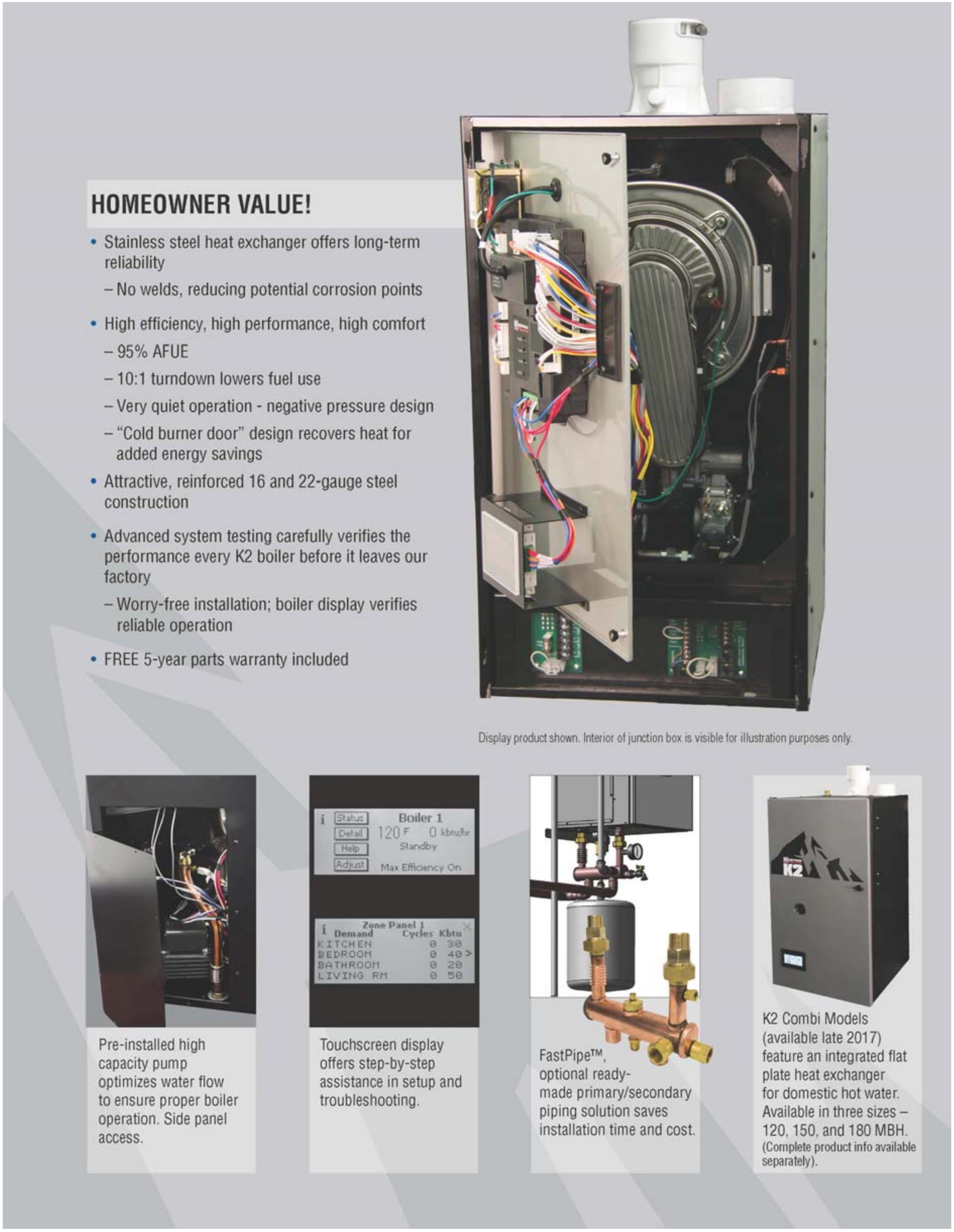
SAVES TIME!

- Intelligent Sage 2.3 Boiler Control System
  - Factory pre-sets offer "out-of-the-box" performance
  - Touchscreen display with step-by-step setup guidance and diagnostics
- Designed for ease of installation & service
  - Hinged control door isolates electronics– Fast and easy access to combustion chamber
  - "Cold burner door" speeds service start
  - Integral, easy access junction box included with separate high voltage and fused, low voltage communication boards
  - Easy clean-out condensate trap
  - Side access panel
- Universal boiler vent connection (polypropylene, CPVC/PVC, and stainless steel flex)

SAVES MONEY!

- Pre-installed premium boiler loop circulator eliminates pump selection and expense

Display product shown. Interior of junction box is visible for illustration purposes only.


HOMEOWNER VALUE!
• Stainless steel heat exchanger offers long-term reliability
– No welds, reducing potential corrosion points
• High efficiency, high performance, high comfort
– 95% AFUE
– 10:1 turndown lowers fuel use
– Very quiet operation - negative pressure design
– "Cold burner door" design recovers heat for added energy savings
• Attractive, reinforced 16 and 22-gauge steel construction
• Advanced system testing carefully verifies the performance every K2 boiler before it leaves our factory
– Worry-free installation; boiler display verifies reliable operation
• FREE 5-year parts warranty included
Display product shown. Interior of junction box is visible for illustration purposes only.
Status
Detail
Help
Adjust
Boiler 1
120 F
0 kbtu/hr
Standby
Max Efficiency On
Zone Panel 1
Demand
Cycles
Kbtu
KITCHEN 0 30
BEDROOM 0 40
BATHROOM 0 20
LIVING RM 0 50
K2
Pre-installed high capacity pump optimizes water flow to ensure proper boiler operation. Side panel access.
Touchscreen display offers step-by-step assistance in setup and troubleshooting.
FastPipe™, optional ready-made primary/secondary piping solution saves installation time and cost.
K2 Combi Models (available late 2017) feature an integrated flat plate heat exchanger for domestic hot water. Available in three sizes – 120, 150, and 180 MBH. (Complete product info available separately).

K2: Technical Information

Standard Equipment

- Direct vent, 10:1 turndown, sealed combustion appliance
- Stainless steel heat exchanger
- Pre-installed boiler loop circulator
- Easy access control panel on hinged door
- Separated high and low voltage junction box
- Sage2.3 Control System
  - LCD touch screen display
  - Self-guided control menus
  - Built-in self diagnostics
  - (2) additional circulator outputs available
  - Built-in sequencer, stages up to (8) boilers
  - Outdoor reset including outside sensor
  - DHW priority
  - Warm weather shutdown
- Variable speed combustion blower
- Gas valve
- Polypropylene condensate trap
- Flow switch, pre-installed
- Supply, return, and auto reset high limit water sensors
- Universal exhaust vent connection (CPVC/PVC, PP, SS)
- Flue gas temperature sensor and differential pressure switch
- Pre-installed hanging bracket and wall mount kit
- Field adjustable for high altitude

K2 Ratings & Specifications

Model	%	Input (MBH) min-max	DOE Heating Capacity (MBH)	Net AHRI (MBH)	Vent Size (Inches)	Approx. Net Weight (lbs.)
K2WT-080B	95.0	8-80	74	64	2 or 3	100
K2WT-100B	95.0	10-100	94	82	2 or 3	102
K2WT-120B	95.0	12-120	112	97	3	105
K2WT-150B	95.0	15-150	142	123	3	119
K2WT-180B	95.0	18-180	169	147	3	119
K2WT-180M	94.5	18-180	168	146	3	119

Safety Relief Valve Pressure, Water – 30 PSI std. ASME certified "H". Maximum Allowable Working Pressure at 50 PSI, Max allowable temperature setting 210°F. Target setpoint is 180°F, manual reset high limit setpoint is 210°F. Boilers shipped set for natural gas. Above performance is for elevations to 2000'. Consult Installation, Operating, and Service Instructions for installations up to 10,100'. 180M model is only for installations osver 2,000'

Optional Equipment:

- Natural gas; LP conversion kit for elevations to 2000' sold separately:
  080B-100B P/N: 107873-01
  120B-150B P/N: 107874-01
  180B P/N: 107875-01
  180M P/N: 108101-01
- FastPipe primary/secondary adapter PN:
  80-120 MBH – (106259-01)
  150, 180 MBH – (106259-02)
- Sage Zone Control
  (Circulator Panel P/N: 104590-01)
  (Valve Panel P/N 104589-01)
- LWCO kit (P/N: 105591-01)
- Service parts kit (P/N: 106260-03)
- Floor stand kit (P/N: 108017-01)
- Kit, CPVC starter and PVC vent terminations
  (2" P/N: 107039-01, 3" P/N: 107039-02)

Typical Venting Configurations
(Horizontal and Vertical–up to 135 eq.ft.each)

Illustrations are for representation only. For complete venting information, please see Installation, Operating, and Service Instructions.


Horizontal 2-pipe


Vertical 2-pipe


Horizontal 2-pipe low profile

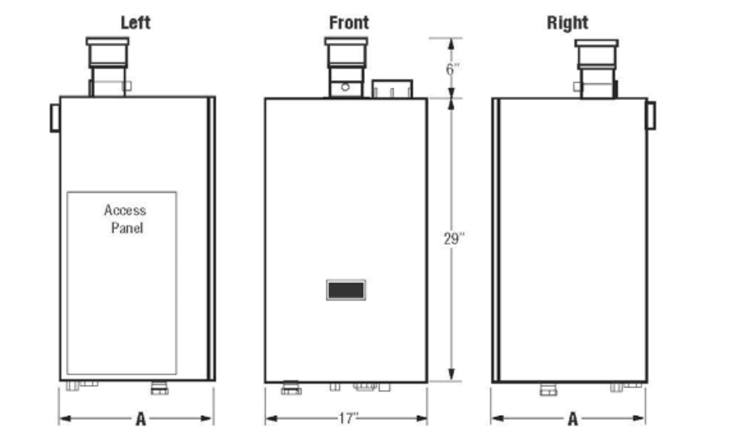

Vertical 2-pipe concentric

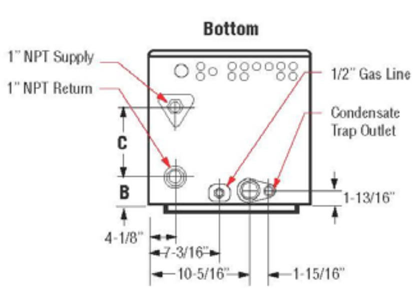

Horizontal 2-pipe concentric

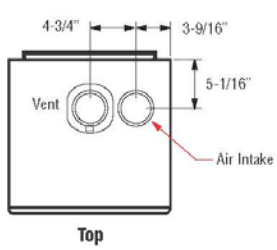

Hybrid

Vertical exhaust/sealed B-vent for combustion air

PLUS polypropylene & stainless steel chimney chase options







K2 Dimensions (Inches)

Model	A*	B	C
K2WT-080B	16-3/16	3	7-3/8
K2WT-100B	16-3/16	3	7-7/16
K2WT-120B	16-3/16	3	7-7/16
K2WT-150B	20-3/16	4-7/16	8
K2WT-180B/M	20-3/16	4-7/16	8

*Open control door extends dimension additional 15"

Form No. USBL14061 20m 9/17

U.S. Boiler Company

www.usboiler.net

Lancaster, PA
Phone: 1-888-432-8887

Sermeta Isothermic Condensing Heat Exchanger

SERMETA

Home | Company | Technology | Innovations | Products | Exhibitions | Contact

Heating range   Hot water range

ISOTHERMIC®

THE reference in condensing gas heat exchangers for domestic applications

Isothermic® is equipped with Sermeta hydroformed tubes technology, as well as a double stainless steel / composite envelope. It is intended for the domestic and commercial heating and combi boilers markets.

91 - 256 MBtu/h

PRODUCT BENEFITS +

EASE OF MAINTENANCE	+
LOW FUME PRESSURE LOSSES	+
LIGHTWEIGHT	+

THE SERMETA SIGNATURE

RELIABILITY	+
LONGEVITY	+
ECOLOGY	+
QUALITY	+

MAXIMUM POWER		DIMENSIONS (WITHOUT DOOR)
DHW (MBtu/h)	Heating (MBtu/h)	L x W x H (in)
91	91	8.14 x 11.41 x 13.97
136	121	8.93 x 11.41 x 13.97
182	159	9.48 x 11.41 x 13.97
256	227	11.84 x 11.41 x 13.97

Sermeta NHEXT Commercial/Industrial Heat Exchanger

NHEXT®

The most advanced heat exchanger water tube technology

Technological breakthrough for commercial and industrial applications, the NHEXT® offers exceptional performance at output up to 4,000 MBtu/h.
The new coil design associated with the central manifold optimizes the water flow. The 4 fume passes provide an unmatched performance.
The NHEXT® benefits from the latest Sermeta innovations!

400 - 4000 MBtu/h

MAXIMUM POWER	DIMENSIONS (WITH DOOR)	WEIGHT
Heating (MBtu/h)	L x W x H (in)	Lbs
400	18 x 18.8 x 23.6	146
500	19.4 x 18.8 x 23.6	152
650	23.7 x 18.8 x 23.6	192
800	30.2 x 18.8 x 23.6	214
1,000	34.1 x 18.8 x 23.6	251
1,250	35.9 x 27.7 x 35.4	463
1,500	40.7 x 27.7 x 35.4	518
2,000	48.9 x 27.7 x 35.4	611
3,000	59.4 x 39.3 x 47.5	1,151
4,000	75.6 x 39.3 x 47.5	1,433

U.S. Patent Application "Surface Combustion Burner"

US 20150167967A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2015/0167967 A1**

Le Mer (43) **Pub. Date: Jun. 18, 2015**

(54) **SURFACE COMBUSTION GAS BURNER**

(71) Applicant: **Sermeta**, Morlaix (FR)

(72) Inventor: **Joseph Le Mer**, Plouezoch (FR)

(73) Assignee: **SERMETA**, Morlaix (FR)

(21) Appl. No.: **14/412,277**

(22) PCT Filed: **Jul. 3, 2013**

(86) PCT No.: **PCT/EP2013/064058**

§ 371 (c)(1),
(2) Date: **Dec. 31, 2014**

(30) **Foreign Application Priority Data**

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Publication Classification

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F23D 14/58 (2006.01)
F23D 14/02 (2006.01)

(52) **U.S. Cl.**
CPC ***F23D 14/14*** (2013.01); ***F23D 14/02*** (2013.01); ***F23D 14/586*** (2013.01)

(57) **ABSTRACT**

The invention concerns a surface-combustion gas burner comprising a combustion grate consisting of a metal sheet pierced with a series of slots. This burner is remarkable in that said metal sheet comprises a series of deflectors made in one piece with said metal sheet and protruding on the outer face of same, each deflector extending longitudinally and laterally above the entire surface of a slot, and in that each deflector comprises a guide portion for guiding the gas flow and a junction portion joining to the metal sheet, said guide portion being spaced from the metal sheet in such a way as to provide therewith at least one lateral gas ejection port, said deflectors being disposed in pairs in such a way that the lateral gas ejection ports of same face each other.

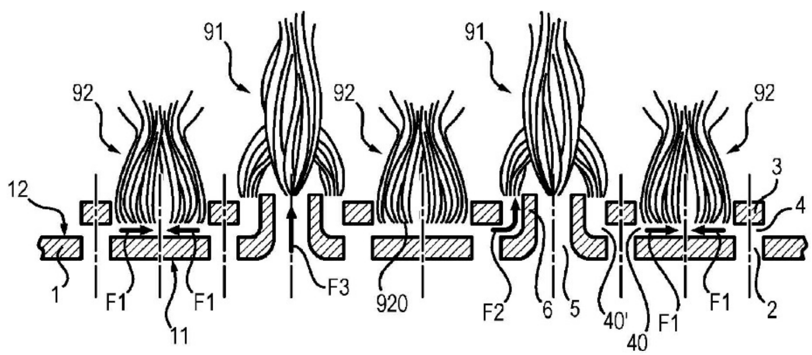
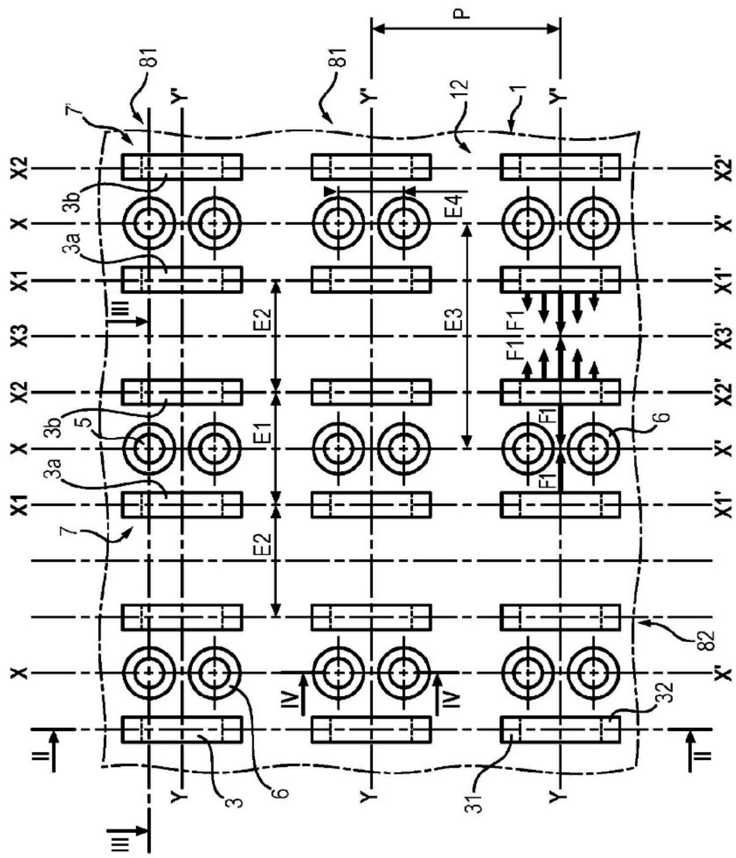


FIG. 1


X2
X
X1
X3
X2'
X'
X1'
X3'
Y
Y'
P
E1
E2
E3
E4
F1
81
82
12
1
7
7'
3a
3b
5
6
3
31
32
II
III
IV

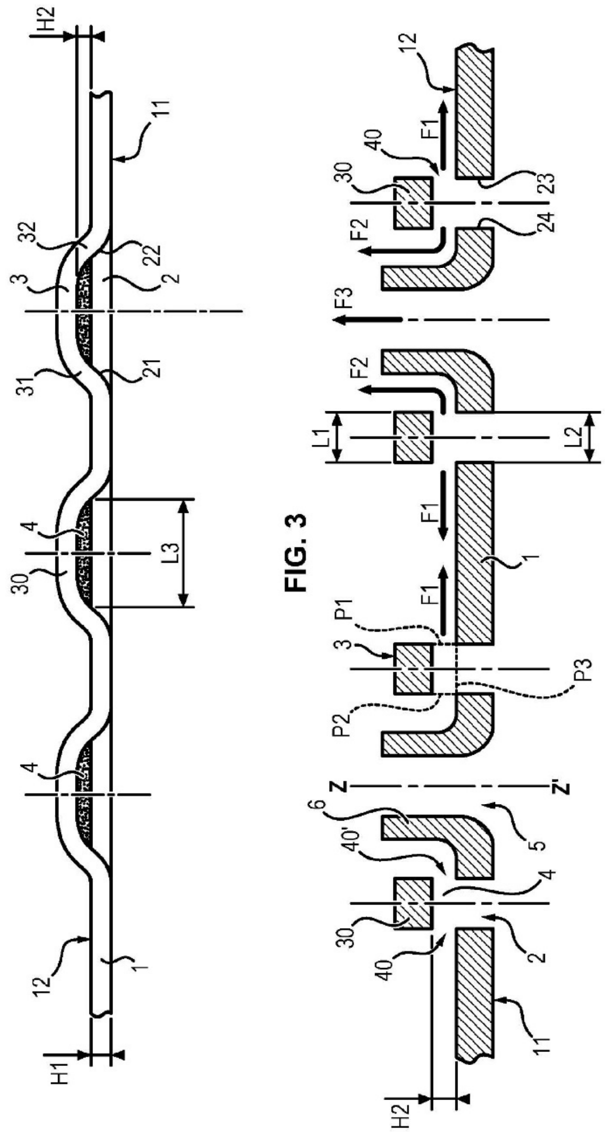

H2
11
32
22
3
2
31
21
4
L3
30
4
12
1
H1
12
F1
40
30
23
F2
24
F3
L1
L2
P1
3
P3
P2
Z
Z'
6
40'
5
4
2
11
H2

FIG. 2

FIG. 3

FIG. 2

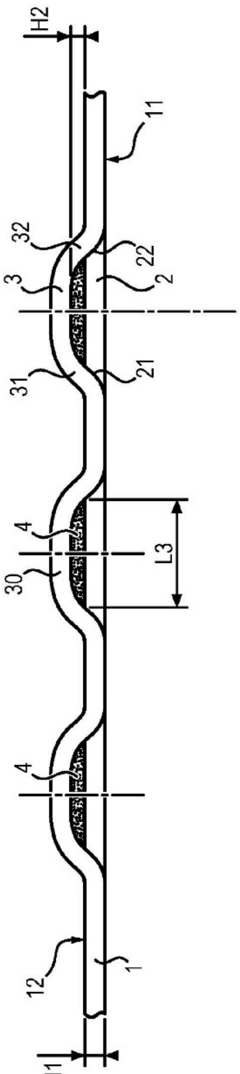

H2
11
32
3
22
2
31
21
4
L3
30
12
1
H1

FIG. 3

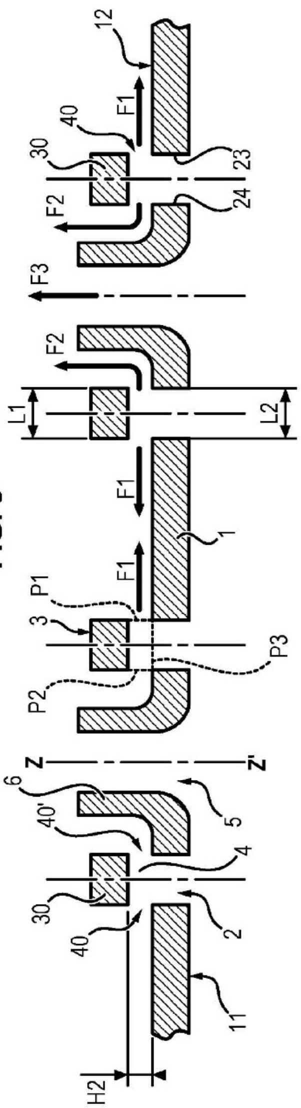

12
40
F1
30
23
24
F2
F3
L1
L2
1
P1
3
P3
P2
Z
Z'
6
40'
5
4
2
11
H2

FIG. 4

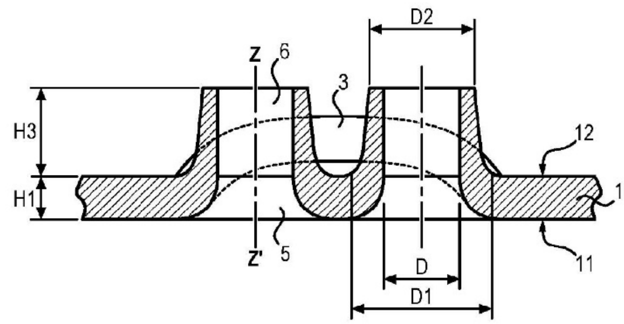


FIG. 5

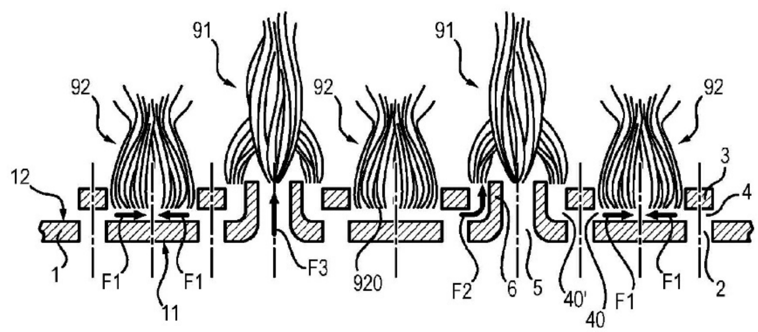


FIG. 6

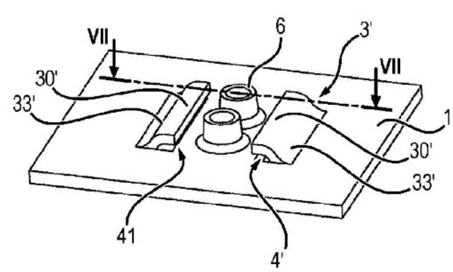


FIG. 7

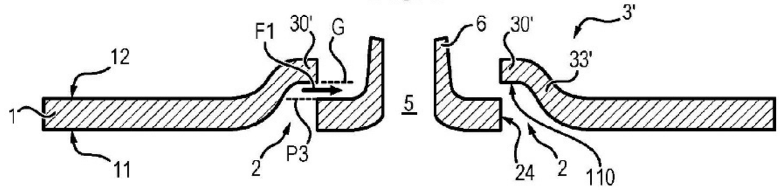


FIG. 8

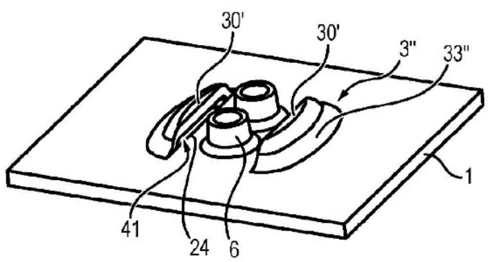


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FIG. 9

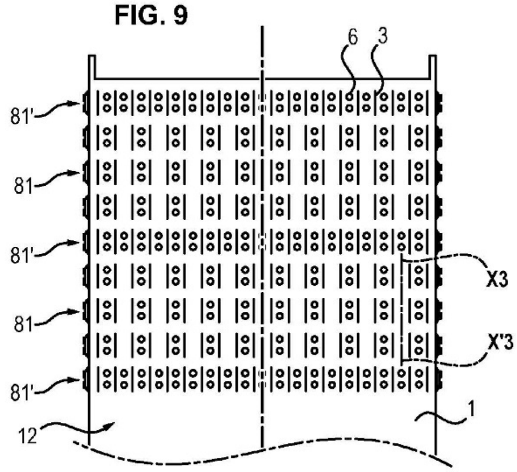


FIG. 10

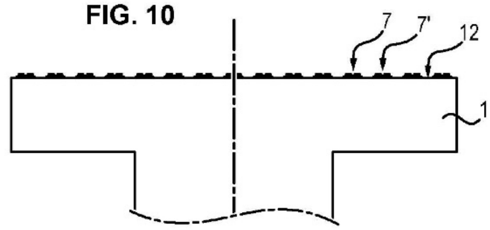


FIG. 11

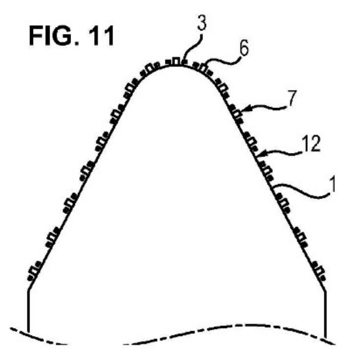
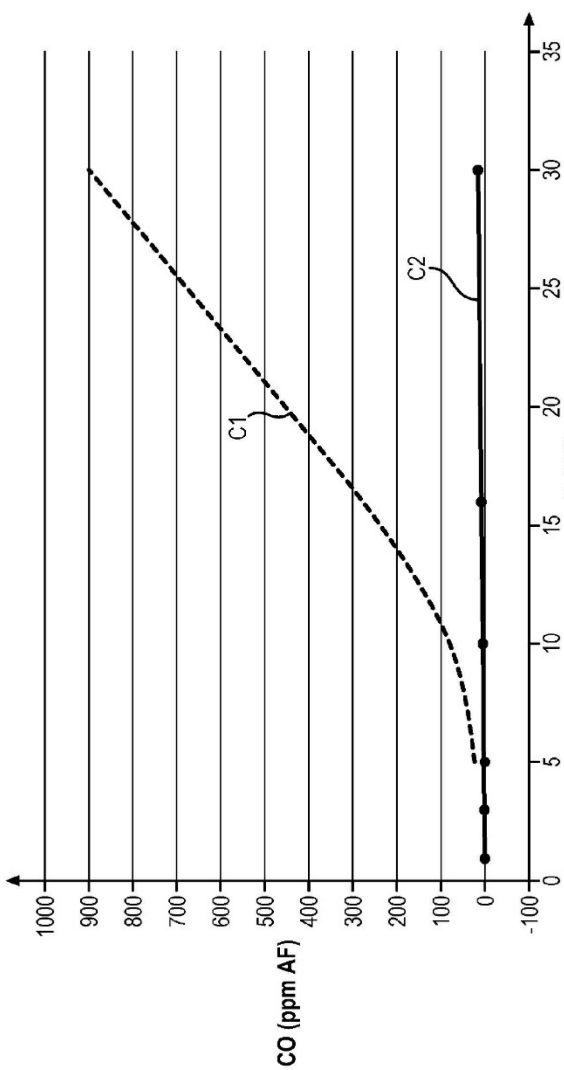


FIG. 12


CO (ppm AF)
1000
900
800
700
600
500
400
300
200
100
0
-100
0
5
10
15
20
25
30
35
P (kW)
C1
C2

SURFACE COMBUSTION GAS BURNER

[0001] The invention is situated in the field of surface combustion gas burners.

[0002] The term "gas burner"designates a burner supplied in fact with a pre-mixed gas-air mixture. In the description and claims that follow, the term "gap," used for the sake of simplification, actually designates a pre-mixed gas-air mixture.

[0003] A so-called "surface combustion" burner designates, by contrast with a torch flame humor, a burner wherein combustion takes place on a combustion surface or combustion grid, through which the gas-air mixture is routed under pressure.

[0004] This type of burner finds particular but not exclusive application in gas water heaters. The burner generates combustion gases which heat the heat exchanger through which passes the fluid to be heated.

[0005] In this type of gas burner, the flame-holding performance on the combustion surface determines the quality of the combustion of the fuel employed (gas in this case), as well as the power variation range of the burner.

[0006] Moreover, the quality of this combustion, that is the greater or lesser emission of polluting gases into the atmosphere, depends on the flame-holding performance of a burner, on the shape of the burner and on the volume of the enclosure (or combustor) wherein the combustion takes place.

[0007] "Flame-holding" designates the ability of the base of the flame to remain in proximity to the combustion surface.

[0008] Two very widespread types of surface combustion burner are already known from the prior art.

[0009] The first type of burner includes a combustion surface (or combustion grid) consisting of a stainless steel sheet perforated with small holes of varying sizes, as well as with slits of varying dimensions, Such a burner is of Cylindrical Shape, for example. The particular association of small hole regions with it regions, the cross-sections whereof are therefore larger, makes it possible to hold the flame properly, but only for a very narrow range of power variation, that is on the order of 1 to 3.

[0010] This type of burner has the disadvantages mentioned hereafter.

[0011] When this burner is used at low power, that is with a low flow rate of the gas-air premix, its surface undergoes a very strong increase in temperature, (of several hundred degrees), connected with flame contact with the sheet, which causes flashbacks into the burner, which can even lead to destruction of the latter,

[0012] Conversely, when this burner is used at high power, there is a risk, of the flame separating from the surface of the burner, which occurs when the exit speed of the gas is considerably higher than the flame propagation speed, and this has the effect of causing considerable pollutant gas emissions, particularly of nitrogen oxides (NOx) and of carbon monoxide (CO),

[0013] Considering the aforementioned disadvantages, the range of usable power setting for a given burner is therefore rather limited.

[0014] The second known type of burner consists of a perforated steel sheet, covered with a layer of stainless steel fibers placed on the outer surface of the perforated sheet. This layer of fibers has a thickness on the order of 1 mm to 2 mm and plays the role of a rather high-performance flame-holder as well as the role of a thermal insulator to reduce the temperature rise of the perforated sheet and thus reduce the risk of flashback.

[0015] This type of burner allows a wider power variation range than the first type Of burner, that is on the order of 1 to 5, or even 1 to 10 depending on the texture of the steel fiber used. This steel fiber, however, is expensive, which increases the total cost of the burner

[0016] The present invention therefore has the purpose of providing a surface combustion gas burner which solves the aforementioned disadvantages and which in particular allows several goals to be attained simultaneously, to wit:

- [0017] very high flame-holding performance, but with the flame slightly separated from the burner so as to reduce the temperature of its combustion surface,
- [0018] the possibility of using it over a wide power variation range,
- [0019] increased burner lifetime due to a considerable reduction in its operating temperature, this being the case at all power settings used,
- [0020] a combustion scheme that is adaptable to burners with a great variety of shapes, and both small and very large dimensions,
- [0021] a considerable reduction in pollutant gas emissions, and particularly of CO and NOx, and
- [0022] low cost, considerably less than that of a burner having a steel fiber coating.

[0023] To this end, the invention relates to a surface combustion gas burner including a combustor grid consisting of a sheet made of metal or refractory material, perforated with a series of slits.

[0024] In conformity with the invention, said sheet includes a series of deflectors integral with said sheet and protruding from its outer face, each deflector extending longitudinally and laterally above the totality of the surface of a slit; each deflector includes a gas flow guiding part and a part connecting it to the sheet, said guiding part being spaced away from the sheet so as to form with it at least one lateral gas ejection opening; and said deflectors are arranged in pairs, so that their lateral gas ejection openings face one another.

[0025] Thanks to these features of the invention, the burner can be used at very high power without separation of the flame, and conversely at very low power without flashback, which guarantees its sturdiness and its longevity.

[0026] According to other advantageous and non-limiting characteristics of the invention, taken alone or in combination:

- [0027] each deflector is shaped so that the generatrix of the inner face of said gas flow guiding part is parallel to the plane of the slit above which this deflector extends;
- [0028] said deflector is a bridge consisting of a sheet-metal strip having a central part and two ends attached to the two ends of the slit above which it extends, said central part constituting the gas flow guiding part and the two ends constituting the Dart connecting to the sheet, and two lateral gas ejection openings are provided on either side of said bridge;
- [0029] the width of each bridge is equal to the width of the slit above which it is positioned;
- [0030] the ratio of the width L1 of the bridge to the height H2 of the lateral gas ejection opening is at least equal to 0.5.

[0031] said deflector has the form of a hood and includes a longitudinal part, preferably flat, for guiding the gas flow, connected to the sheet by one of its longitudinal sides.

[0032] said deflector has the form of a gill;

[0033] said sheet is further perforated with a series of ports extending into discharging micro-tubes which protrude from its outer face and the central axis whereof is perpendicular to the sheet;

[0034] the ratio of the height H3 of the portion of the discharging micro-tube protruding from the outer face of the sheet and the inner diameter P of this micro-tube is comprised between 0.2 and 2, is preferably equal to 1;

[0035] the slits and ports are grouped so as to form patterns, each Pattern including at least one port extending into a micro-tube positioned between two slits dapped by a deflector;

[0036] each pattern includes two openings each extending into a micro-tube, positioned between two slits capped by a deflector, both slits being parallel to the axis of alignment of these two parts;

[0037] said combustion grid has a cylindrical shape;

[0038] said combustion grid is of flat circular shape, of domed circular shape, or of dihedral shape.

[0039] Other features and advantages of the invention will appear from the description which will now be given, with reference to the appended drawings which show, by way of indication but without limitation, several possible embodiments of it.

[0040] In these drawings:

[0041] FIG. **1** is a top view of a portion of the combustion grid of the burner according to the invention,

[0042] FIGS. **2**, **3** and **4** are section views of the same combustion grid, taken reflectively in the section planes II-II, III-III and IV-IV of FIG. **1**, FIGS. **3** and **4** being at a larger scale,

[0043] FIG. **5** is a schematic view showing the principle for holding the flame on the surface of the burner grid,

[0044] FIGS. **6**, **7** respectively are views, in perspective and in section along section plane VII-VII of FIG. **6**, of a second embodiment of the openings provided in the combustion grid according to the invention, FIG. **7** being at a larger scale,

[0045] FIG. **8** is a perspective view of a third embodiment of the openings provided in the combustion grid according to the invention,

[0046] FIGS. **9** to **11** show different variant embodiments of the combustion grid, respectively of cylindrical shape, of flat circular shape and of dihedral shape with a rounded peak, and

[0047] FIG. **12** is a graphic showing carbon monoxide (CO) emission as a function of the gas power P of the burner, for a prior art burner and one conforming to the invention.

[0048] A first embodiment of a gas burner according to the invention will, now be described with reference to FIGS. **1** through **4**.

[0049] This burner includes a combustion grid. It is connected to means, not shown, a fan for example, configurated for delivering a gas-air mixture, natural gas with air for example, under pressure, to the inside of the burner. The gaseous mixture passes through the openings and ports of the grid and combustion is initiated on its outside face thanks to an ignition system known to the person skilled in the art.

[0050] This combustion grid consists of a sheet (or plate) **1** made of metal, of stainless steel for example, or of refractory material. These inner and outer faces are respectively labeled **11** and **12**.

[0051] This sheet **1** is perforated with a series of slits **2**, of generally rectangular shape, each slit **2** having two longitudinal edges **23**, **24**.

[0052] Each slit **2** is capped with a bridge **3** or “little bridge”, which is in one piece (formed integrally) with said sheet **1** and which protrudes from the outer surface **12** thereof.

[0053] As will be described later in more detail, the bridge **3** plays the role of a deflector for the gas passing through the sheet **1**

[0054] Each bridge **3** consists of a strip of sheet metal curved or formed so that its concavity is oriented toward the slit **2**. The bridge has a central part (portion) **30** and two ends **31**, **32** which are attached respectively to the two ends **21** and **22** of the slit **2** above which this bridge extends longitudinally and laterally. The central part **30** constitutes a gas flow guiding part and the ends **31**, **32** a connection part to the sheet **1**.

[0055] Preferably, the slits **2** are made using appropriate punching dies, not shown in the figures for the sake of simplification.

[0056] Preferably, the width L1 of the bridge **3** is equal to the width L2 of the slit **2** above which it is positioned (see FIG. **3**).

[0057] The travel of the punching die defines the height H2 of a space **4**, provided between the bridge **3** (more precisely its central part or portion **30**) and the slit **2**.

[0058] The spacing between the bridge **3** and the outer face **12** of the sheet **1** located in proximity to the bridge allows two openings (or holes) **40** and **40'** to be defined, called “lateral gas ejection openings,” on either side of the space **4** (see FIG. **3**).

[0059] These lateral gas ejection openings **40** and **40'** lie respectively in the planes P1 and P2 which are mutually parallel and also perpendicular to the plane P3 of the slit **2**. In the remainder of the description and of the claims, this plane P3 of the slit **2** is taken to be at the outer face **12** of the sheet **1**.

[0060] Advantageously, and as is better seen in FIG. **1**, the bridges **3** are all of the same length and are arranged parallel to one another and aligned with a median axis Y-Y' which is perpendicular to them.

[0061] The different bridges **3** are therefore arranged in the form of lines **81** or row (horizontal in FIG. **1**).

[0062] The bridges **3** are arranged in pairs, the lateral openings **40**, **40'** whereof face one another.

[0063] Also preferably, the bridges **3** in different lines **81** are aligned with a longitudinal axis X1-X'1 or X2-X'2 perpendicular to Y-U' , so as to define a column of bridges **82** (vertical in FIG. **1**).

[0064] Advantageously but not compulsorily, the bridges **3** are arranged with a constant spacing E1, and E2 (E1=E2).

[0065] According to a simplified variant of the invention, the sheet or plate **1** is provided only with slits **2** and bridges **3**. Advantageously, however, another type of perforation with a particular geometry is also practiced on the entire sheet **1**.

[0066] These are ports **5** extending into discharging micro-tubes **6** which protrude from the outer face **12** of the sheet **1**.

[0067] Preferably, the ports **5** are circular and the micro-tubes **6** are cylindrical, so that they have a central axis or axis of revolution Z-Z' perpendicular to the sheet **1** (see in particular FIGS. **3** and **4**).

[0068] The discharging micro-tubes **6** thus constitute gas micro-injectors. These micro-tubes **6** have the effect of considerably increasing the thickness of the sheet **1** at the location where they are formed.

[0069] The ports **5** and the micro-tubes **6** are obtained for example by drawing, which has the effect of stretching the material of the sheet.

[0070] Due to this, the outer diameter D1 of the base of these micro-tubes **6**, at their interface with the outer face **12** of the sheet **1**, is greater than their outer diameter at the tip, D2. The thickness of the wall of the micro-tube is thus frusto-conical.

[0071] The slits/bridges and the ports/micro-tubes can be arranged and grouped on the sheet **1** so as to form different patterns **7**.

[0072] According to a preferred variant embodiment of the invention shown in FIG. **1**, the micro-tubes **6** are grouped in pairs and are aligned two by two along an axis X-X', while a slit **2** and a bridge **3** are positioned on either side of this pair of ports **5**/micro-tubes **6**, so that their longitudinal axes X1-X'1 or X2-X'2 are parallel to the axis X-X'.

[0073] It is also possible to have only one micro-tube **6** or more than two between the two bridges **3**.

[0074] Moreover, these patterns **7** can be arranged and repeated over the plate **1** so that the spacing E1 between the longitudinal axes X1-X'1 and X2 -X'2 respectively of the left **3***a* and right **3***b* bridges of a first pattern **7** is equal to the spacing E2 between the longitudinal axis x2-x'2 of the right bridge **3***b* of this pattern **7** and the longitudinal axis X1-X'1 of the left bridge **3***a* of a second adjoining pattern **7'** located to the right of the first pattern **7**. In other words, the spacing E3 between two alignment axes X -X' of micro-tubes **6** is twice the value of the spacing E1 between two, left **3***a* and right **3***b* in bridges of one and the same pair. This feature is not compulsory.

[0075] In the example shown in FIG. **1**, it is observed that there are no ports **5** and mico-tubes **6** between the right bridge **3***b* of a first pattern **7** and the left bridge **3***a* of the adjoining pattern **7'**. In other words, along an axis X3-X'3 parallel to X2-X'2, there are no gas exit ports. Such an arrangement thus makes it possible to increase the flow of as in the portion of the burner having patterns **7** and **7'**, and conversely to provide the zones with axes X3-X'3 where there is little gas release.

[0076] However, as can be seen in FIG. **9** which shows an exemplary embodiment wherein the burner has a cylindrical shape, it is also possible to provide pairs of openings **5**/micro-tubes **5** between the totality of the bridges **3**. A zone or raw **81'** with a very high coefficient of transparency is thus obtained, as opposed to the rows **81** with a low transparency coefficient where the ports **5** and the micro-tubes **5** are absent from lines X3-X'3. These rows with differences in their coefficients of transparency can be alternated in different ways. The transparency coefficient refers to the ratio between the total area of the ports and the total area of the plate **1**.

[0077] Other variant embodiments can also be contemplated. For example, FIG. **11** shows the case of a burner with a flat circular surface. In this case, the different rows **81**, or **81'**, of patterns **7**, are aligned parallel with one another. However, it would also be possible to provide for a radial arrangement in which all the different axes X-X', X1-X'1, X2-X'2 and X3-X'3 would be radial and intersecting at the center of the circular burner.

[0078] It will be noted that the dimensional proportions of the slits, bridges, ports openings and micro-injectors play a role in the desired result of improving combustion performance.

[0079] Thus preferably the ratio L1/H2 is at least equal to 0.5. Also preferably, the ratio H3/D is comprised between 0.2 and 2, more preferably equal to 1.

[0080] Other embodiments of the deflectors, other than the bridges **3**, will now be described in connection with FIGS. **6** through **8**.

[0081] According to a first embodiment shown in FIG. **5**, the deflector labeled **3'** has the general shape of a "hood" or "awning" and includes a preferably flat longitudinal portion **30'** which extends longitudinally above the totality of the length of the slit **2** and which makes it possible to guide the gas flow. It is connected, along one of its longitudinal sides, with the sheet **1** with which it is integrally formed, by an arched portion **33'**.

[0082] A space **4'** is provided between the portion **30'** and the slit **2** and there is a single lateral gas ejection opening **41** between the portion **30'** and the sheet **1**.

[0083] These two deflectors **3'** are positioned facing one another, so that their respective openings **41** are facing one another. When the micro-tubes **6** are present, the two deflectors **3'** are also advantageously parallel to the alignment axis X-X' of said micro-tubes.

[0084] According to a second variant embodiment shown in FIG. **9**, the deflector has the shape of a "gill" **3"** which differs from the awning or hood **3'** by the circular-arc shape of its portion **33"** connecting to the plate **1**.

[0085] Finally, it will be noted that whatever the technique and/or means for producing the deflector(s) **3**, **3'**, **3"**, these cover the totality of the surface area of the slit **2**.

[0086] The view of FIG. **1** shows only a portion of the sheet **1**, viewed from top, hence flat. However, the burner made from this sheet can have different geometric shapes.

[0087] According to one preferred variant embodiment shown in FIG. **9**, the combustion grid of the burner has a cylindrical shape; its upper face is plugged by a disk and its side wall has the perforation patterns **7**, **7'** described previously. It will be noted that it would also be possible to provide these patterns only on a circular arc portion of this cylinder.

[0088] Advantageously, the axes X1-X'1 and X2 -X'2 of the bridges (and hence of the slits **2**) are parallel to the axis of revolution of the cylindrical burner.

[0089] FIG. **10** shows a burner the combustion grid whereof is circular and flat. Although this is not shown, this grid can also be slightly domed, so that its outer surface is convex, its concavity being oriented toward the gas supply (toward the bottom of FIG. **10**).

[0090] Finally, as shown as in FIG. **11**, the plate **1** can be slightly arched longitudinally in a dihedral shape, so as to exhibit a substantially triangular straight section with a rounded upper point.

[0091] The operation of the burner conforming to the invention is the following.

[0092] As can be seen in FIGS. **3** and **5**, the gas escape through a port **5** and from the micro-tube **6** takes place in a direction perpendicular to the plane of the sheet and hence to its outer face **12** (arrow F3).

[0093] Moreover, the gas which leaves the slit **2** perpendicularly to the plane of the sheet **1** hits the deflector, more precisely its central gas flow guiding part **30**, which extends above the entire surface area of said silt, so that it cannot escape perpendicular to the sheet **1**.

[0094] For this reason, the escape of the gas occurs to either side of the bridges **3**, through lateral gas ejection openings **40** and **40'**.

[0095] Through the opening **40** with no micro-tube **6** in front of it, this gas escape occurs parallel to the outer face **12** of the sheet (arrow F1), or tangentially if the sheet **1** is curved (in the case of a cylindrical burner). This gas escape through the lateral as ejection opening **40** thus takes place perpendicularly to the axis of the gas jets (arrow F3) leaving the adjoining micro-tubes **6**, or quasi-perpendicularly to this direction F3 if the gas escape is tangential.

[0096] Moreover, the gas leaving the opening **40'**, located in front of a micro-tube **6**, is also directed parallel to the face **12** or tangentially thereto then, once it hits the micro-tube **6**, is then deflected outward (arrow F2), parallel to the jets leaving the micro-tubes **6** (arrows F3). In addition, and as can be seen in FIG. **1**, the gas leaving the opening **40'** between the two tubes **6** is also directed in the direction of the arrows F1.

[0097] Preferably, and as can be seen in FIG. **7**, the generatrix G of the inner face **110** of the guiding part **30'** of the deflector extends parallel to the plane P3 of the slit **2**. The same is true of the other embodiments of the deflector.

[0098] Thus the gas, which tends to be deflected in a direction parallel to the surface of the deflector that it covers, is guided (arrow F1) parallel to the sheet **1** (or tangentially thereto, if it is curved).

[0099] The generatrix G could also be quasi-parallel to the plane P3 (a slight angular variation is possible), provided that the major portion of the gas flow is guided as aforementioned.

[0100] The combustion zone in a line along the axis X-X' receives not only the gas flow of the pairs of micro-tubes **6** but also the flow of gas leaving the bridges **3** located on either side. This combustion zone shown by the flame **91** in FIG. **5** is called "principal flow type."

[0101] It makes it possible to develop a strong flow through the micro-tubes **6** and the additional flows coming from the bridges **3** accentuate the adhesion of the flame to the tips of the micro-tubes **6** with an impressive performance, even for very large gas flow ranges.

[0102] Advantageously, these principal flow type combustion zones **91** are alternated with combustion zones **92** called, "secondary flow type," which extend along axes X3-X'3 and which receive only the flow of gas of the bridges **3** (arrows F1 in FIG. **1**, **3** and **5**).

[0103] The face-to-face encounter of these to gas flows parallel or tangential to the wall of the sheet **1** and which come from the lateral openings **40** (see arrows F1), causes combustion near the outer face **12** of the sheet **1**, in a zone free of perforations. The base **920** of this flame **92** is slightly separated from the face **12**, because this face is free of the heavy flow of the micro-tubes **6**. Moreover, the gas which circulates on the side of the inner face **11** of the combustion grid contributes to cooling this wall, which glows red only slightly.

[0104] This bidirectional distribution of the gases (arrows F1 and F3) at the surface of the sheet **1** of the combustion grid makes it possible to perfectly control the holding of the flame and thus allows combustion within a very large flow (and hence power) variation range (greater than **40**), without flashback or separation flame.

[0105] For a given burner area, the transparency coefficient plays an important role in the behavior of the combustion that is obtained, depending on the gas flow for different desired ranges of power.

[0106] With prior art burners, the greater the coefficient of transparency, the higher the maximum power. However, the minimum power will also be high if flashbacks are to be avoided. For this reason, the range of per variation is reduced for a given burner.

[0107] On the contrary, with the present invention, it becomes possible to use the burner over a very large amplitude of power variation.

[0108] The operation described with the bridges **3** is the same with the hoods **3'** or the gills **3"**. Thus, in the absence of micro-tubes **6** between the hoods or the gills, only secondary flow type combustion zones are created, and when they are present, principal flow type combustion zones are created.

[0109] To this excellent flame-holding performance is also added a very low pollution rate with a very low emission of carbon monoxide CO.

[0110] On this topic, reference is made to the curve of FIG. **12**, which represents the quantity of CO emission expressed in ppm, as a function of the burner power expressed in kW (comparative tests carried out using standard separation gas G321, used in laboratories for standardization tests).

[0111] The curve C1 was obtained with a prior art burner, the combustion grid whereof is a perforated sheet which had only a series of slits and ports but without bridges and without micro-tubes. It is observed that this CO emission curve rises progressively when the power is increased beyond 5 kW, this being so from 5 to 30 kW, thus confirming the decay in the cleanliness of combustion by separation of the flame (the CO value below 5 kW cannot be estimated because flashback occurs).

[0112] Conversely, the curve C2 shows the results obtained with the burner according to the invention having alternating patterns of dual micro-tubes and dual bridges, with the preferred dimensions given earlier. It is observed that the CO emission only varies from 0 ppm to 6 ppm for a power variation range from 1 to 30 kW. Other tests performed for NOx show that these are reduced by one-half with the burner according to the invention.

[0113] These results show distinctly the excellent flame-holding performance of the flame and the cleanliness of the combustion resulting therefrom.

[0114] One particular application of this type of burner relates to heat exchangers, and particularly those of domestic and industrial water heaters. It is possible to operate the burner according to the invention at low power, for example to produce hot water needed for central heating of a well-insulated house, and to operate it momentarily at very high powers in case of domestic hot water demand, with "flash" type production.

[0115] Other diverse and varied applications of this burner can be contemplated. Purely by way of illustration, it can be used, for example, in manufacturing lines for glass and for heat-treating it or even in cooking by surface combustion used in agri-food factories.

1. A surface combustion gas burner including a combustion grid consisting of a sheet made of metal or refractory material, perforated with a series of slits, wherein said sheet includes a series of deflectors formed integrally with said sheet and protruding from its outer face, each deflector extending longitudinally and laterally above the totality of the surface of a slit, in that each deflector includes a gas flow guiding part and a part connecting it to the sheet, said guiding part being spaced away from the sheet so as to form with it at least one lateral gas ejection opening, and in that said deflectors are arranged in pairs, so that their lateral gas ejection openings face one another.

2. The gas burner according to claim **1**, wherein each deflector is shaped so that the generatrix of the inner face of said gas flow guiding part is parallel to the plane of the slit above which this deflector extends.

3. The gas burner according to claim **1**, wherein said deflector is a bridge consisting of a strip of sheet metal having a central part and two ends attached to the two ends of the slit above which it extends, said central part constituting the gas flow guiding part and the two ends constituting the part connecting to the sheet, and in that two lateral gas ejection openings are formed on either side of said bridge.

4. The gas burner according to claim **3**, wherein the width of each bridge is equal to the width of the slit above which it is positioned.

5. The gas burner according to claim **3**, wherein the ratio of the width of the bridge to the height of the lateral gas ejection opening is at least equal to 0.5.

6. The burner according to claim **1**, wherein said deflector has the shape of a hood and includes a longitudinal part, preferably flat, for guiding the gas flow, connected to the sheet by one of its longitudinal sides.

7. The burner according to claim **1**, wherein said deflector has the shape of a gill.

8. The gas burner according to claim **1**, wherein said sheet is further perforated with a series of ports extending into discharging micro-tubes, which protrude from its outer face and the central axis whereof is perpendicular to the sheet.

9. The gas burner according to claim **8**, wherein the ratio of the height of the portion of the discharging micro-tube protruding from the outer face of the sheet and the inner diameter of this micro-tube is comprised between 0.2 and 2, and preferably is equal to 1.

10. The gas burner according to claim **8**, wherein the slits and ports are grouped so as to form patterns, each pattern including at least one port extending into a micro-tube positioned between two slits capped by a deflector.

11. The gas burner according to claim **10**, wherein each pattern includes two ports each extending into a micro tube, positioned between two slits capped by a deflector, these two slits being parallel to the axis of alignment of these two ports.

12. The gas burner according to claim **1**, wherein said combustion grid has a cylindrical shape.

13. The gas burner according to claim **1**, wherein said combustion grid is of flat circular shape, of domed circular shape or of a dihedral shape.

* * * * *

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LE MER (43) **Pub. Date: Aug. 2, 2018**

(54) **HEAT EXCHANGER**

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(52) **U.S. Cl.**
CPC ***F23C 5/02*** (2013.01); ***F23C 3/002*** (2013.01); *F27D 2201/00* (2013.01); ***F27D 1/1808*** (2013.01); *F27D 2001/1825* (2013.01); ***F23D 91/04*** (2015.07)

(57) **ABSTRACT**

The invention relates to a heat exchanger (**1**) comprising a shell (**2**) containing a heat exchange device (**3**) and delimiting a combustion chamber (**30**), said shell (**2**) being provided with an access opening and with a door (**5**) provided on its inner face with a burner (**4**).

It is remarkable in that said door (**5**) is mounted pivotally around a pivot (**6**) attached to the end of a slide (**7**), in that said shell (**2**) is provided on its exterior surface with axial guide means (**8**) of said slide (**7**) along a displacement axis X**2**-X'**2** which extends parallel to the longitudinal axis X-X' of said shell (**2**), in that the pivot (**6**) extends along an axis Z-Z' perpendicular to said displacement axis X**2**-X'**2**, the travel of said slide (**7**) being greater than the length of the burner (**4**).

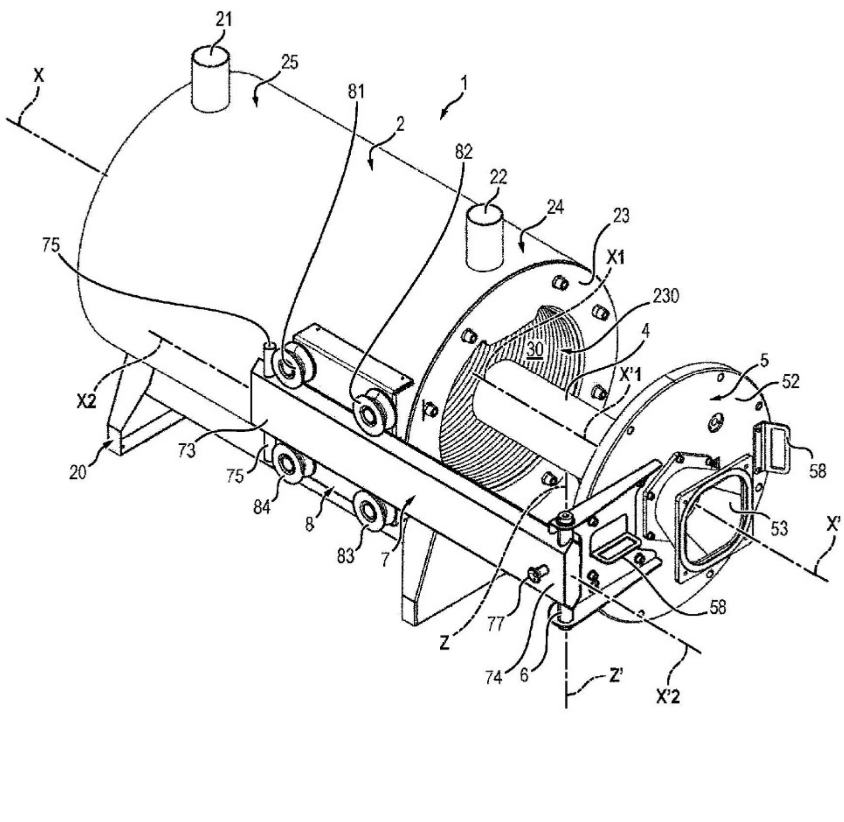
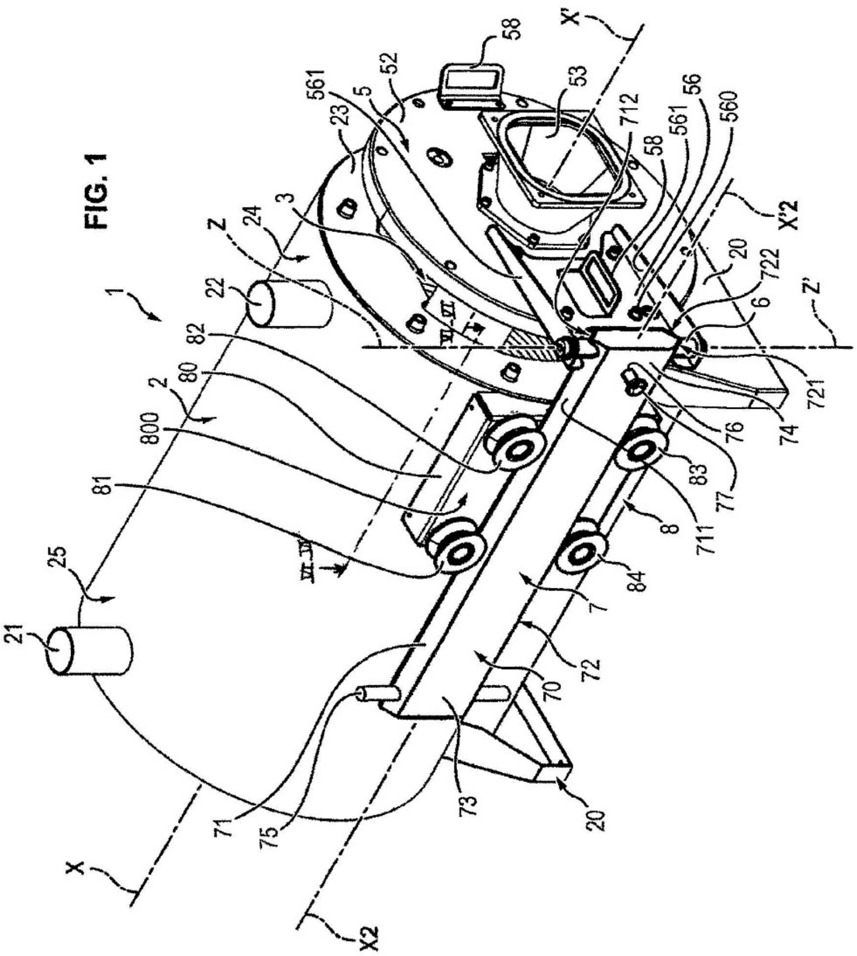


FIG. 1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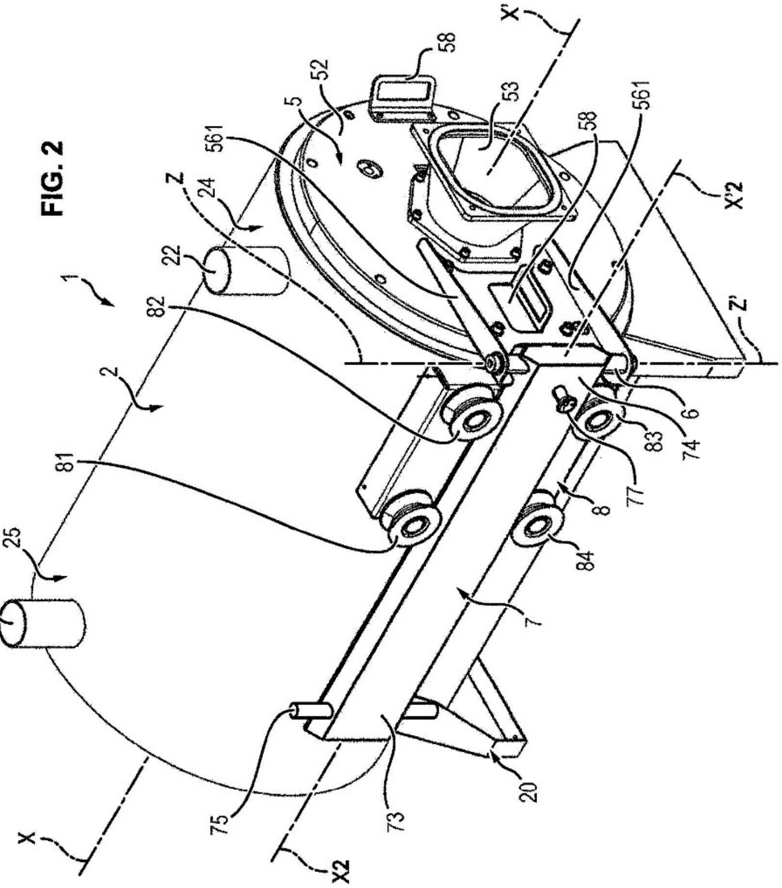
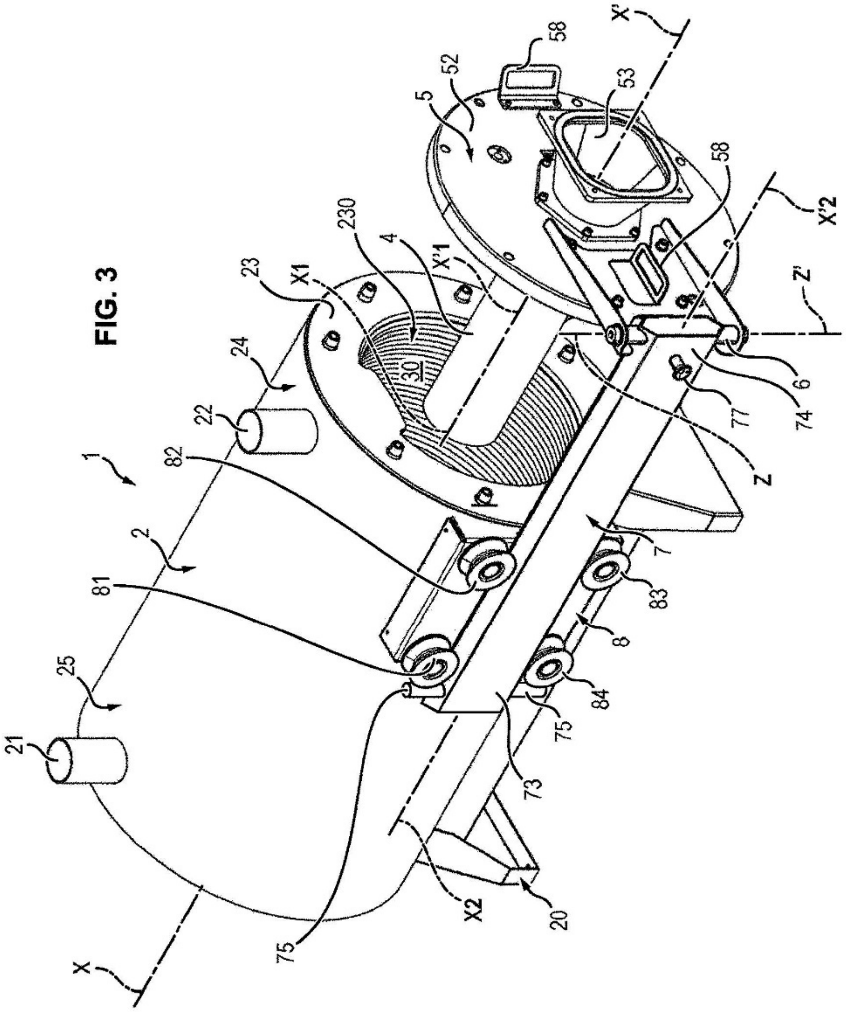
X2
X'2
Z
Z'

FIG. 2

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84
230
X
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X1
X'1
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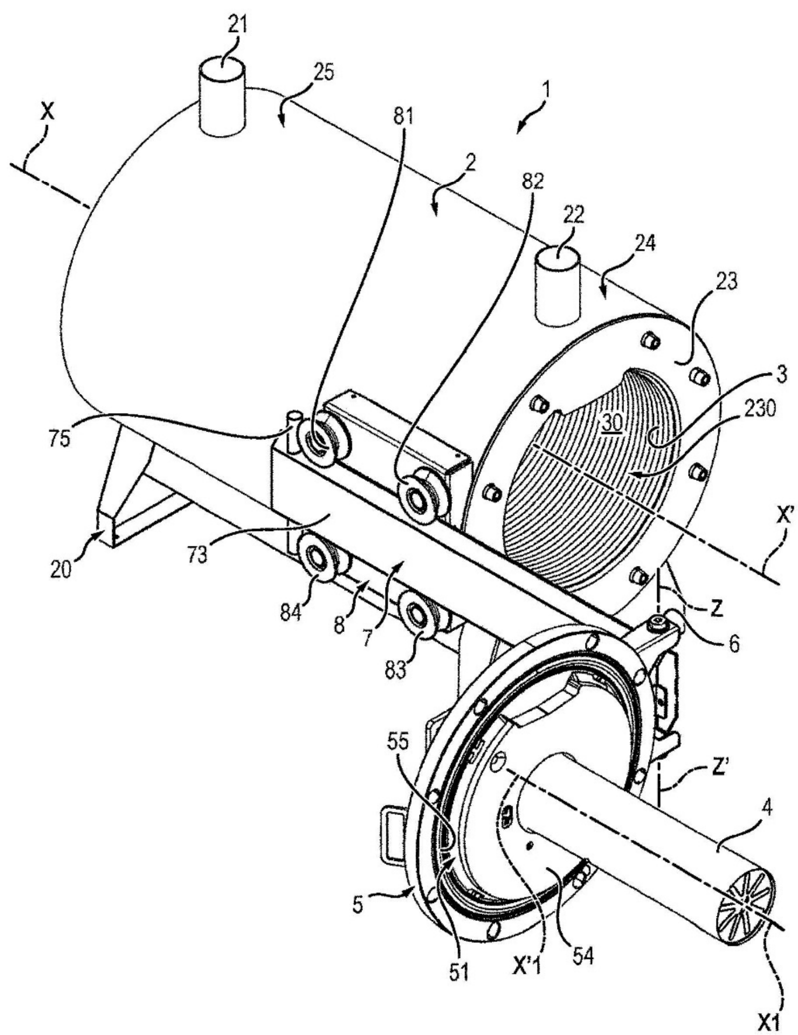
X'2
Z
Z'

FIG. 3

FIG. 4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Z'
4
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X'1
54
X1

FIG. 5

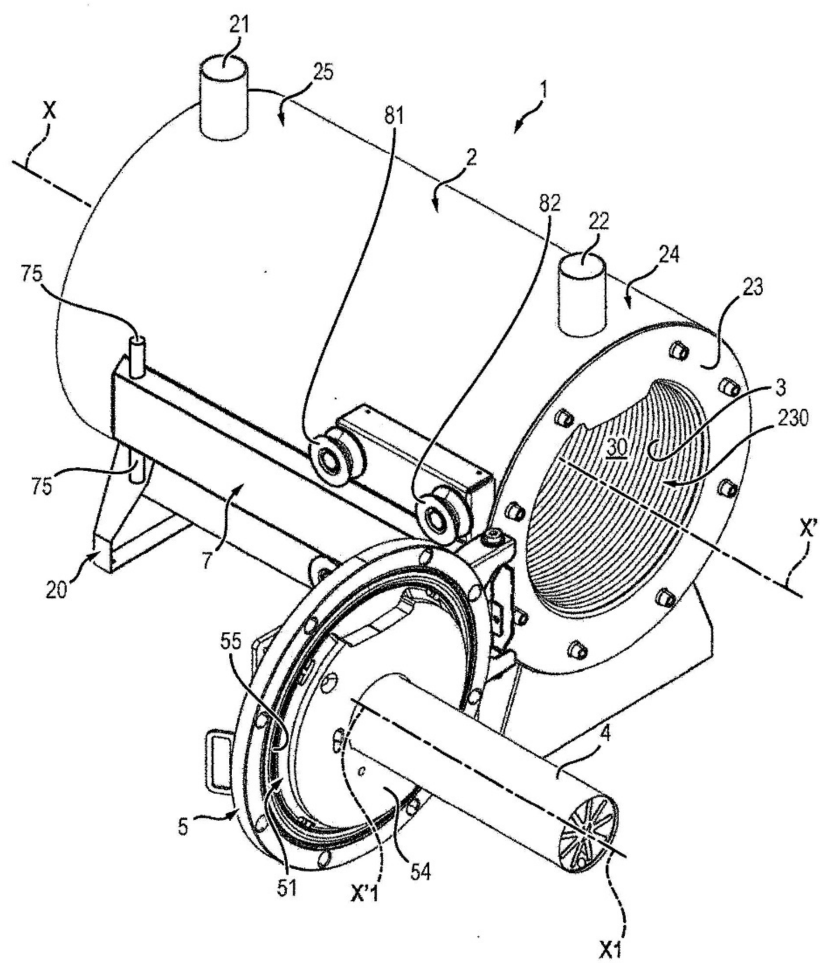
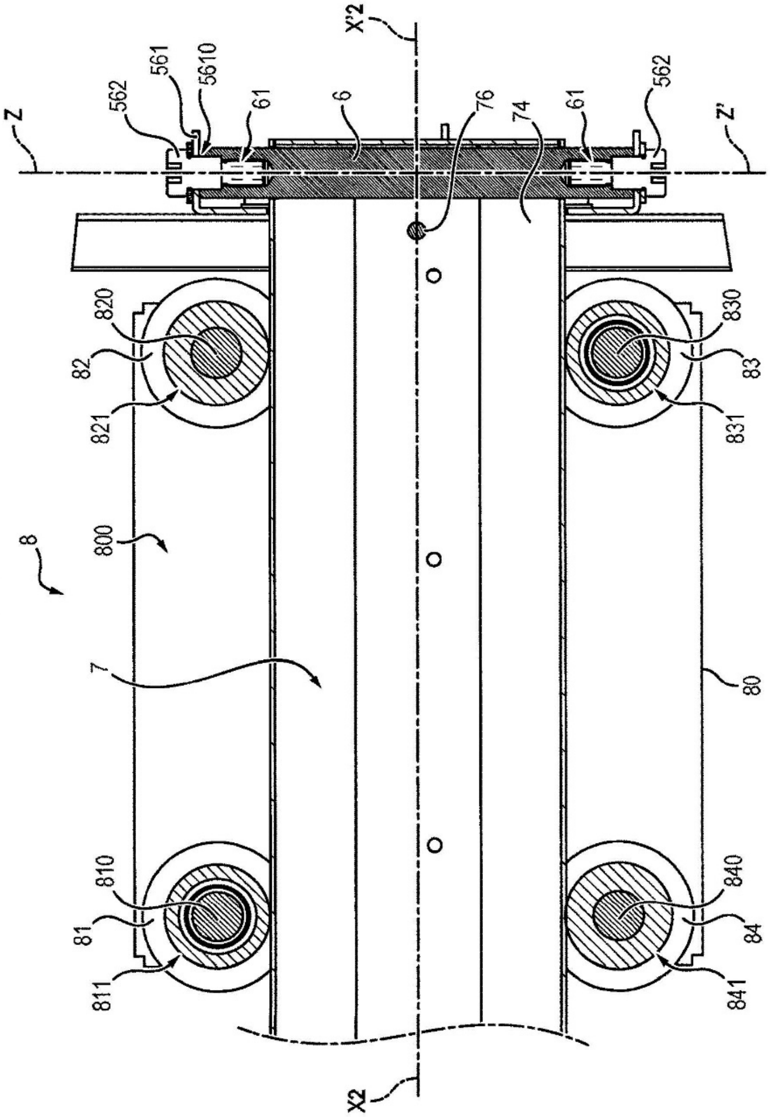


FIG. 6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840
84
841
X2

HEAT EXCHANGER

GENERAL TECHNICAL FIELD

[0001] The invention is situated in the field of heat exchangers, particularly for a gas- or fuel oil-fired boiler.

[0002] The present invention relates more precisely to a heat exchanger comprising a gas-tight shell containing a heat exchange device and delimiting a combustion chamber, said shell being provided with an access opening and with a door suitable for being able to close said access opening, said door being provided with a burner, particularly for gas or fuel oil, protruding from its inner face.

PRIOR ART

[0003] Also known already from document FR2942866 is a heat exchanger as previously mentioned. Its door is also provided on its outer face with a system for bringing a combustible mixture to the burner. Finally, said shell is provided with a sleeve for discharging the burned gasses.

[0004] This door is attached detachably to a framework for said access opening, for example by means of screws.

[0005] However, it is necessary to regularly gain access to the tubes of the exchanger and/or to the burner for maintenance operations.

[0006] The opening of the door is carried out by withdrawing it after unscrewing the screws. This removal must sometimes be carried out using a hoist if this door is bulky and/or heavy, which is the case in particular for high-powered heat exchangers in which the door can attain a diameter of 1 meter and a weight of over 50 kg.

[0007] Also know in the prior art are heat exchangers in which the door is mounted on a hinge attached to the face of the exchanger. However, such a door can only be equipped with a small-sized burner, because a bulkier burner would block the pivoting movement of the door.

PRESENTATION OF THE INVENTION

[0008] The invention has as its aim resolving the aforementioned disadvantages of the prior art and proposing a heat exchanger equipped with an access door equipped with a burner, which allows total and facilitated access both to the burner and to the heat exchange devices, while still avoiding lifting the door, either manually or with a hoist.

[0009] The invention must also allow maintaining the gas-tightness of the exchanger when the door is again closed against its face.

[0010] To this end, the invention relates to a heat exchanger comprising a gas-tight shell containing a heat exchange device and delimiting a combustion chamber, said shell being provided with an access opening and with a door suitable for being able to close said access opening, said door being provided with a burner, particularly for gas or for fuel oil, protruding from its inner face. According to the invention, said door is mounted pivotally around a pivot attached to the so-called "front" end of a slide, or substantially to this front end said shell is provided on its exterior surface with guide means which allow said slide to be guided axially along a displacement axis **X2-X'2** which extends parallel to the longitudinal axis X-X' of said shell, the pivot extends along an axis Z-Z' perpendicular to said displacement axis **X2-X'2**, and the travel of said slide is greater than the length of the burner, so that said door can be moved from a closed position, in which it closes the access opening of said shell, to a so-called "spaced-apart" position, in which it is separated from this access opening and in which the burner is located outside the shell, and said door being able to pivot around the pivot when it is located in said "separated" position.

[0011] Thanks to these features of the invention, the burner can be completely withdrawn from the exchanger, which facilitates its cleaning and possible interventions on the insulator that surrounds it. Moreover, the door remains attached to the slide and is supported by it. It is therefore no longer necessary to lift it.

[0012] Finally, in the closed position of the door, the gas-tightness of the exchanger is guaranteed.

[0013] According to other advantageous and non-limiting features of the invention, taken alone or in combination:

[0014] the door can pivot around the pivot at an angle of at least 180°;

[0015] the slide is provided with an end-of-travel stop which prevents it from leaving the guide means;

[0016] the slide is a strip having an upper face and a lower face and the guide means comprise two upper rotating rollers and two lower rotating rollers in the shape of twin wheels, mounted as idlers, provided with a groove the profile of which corresponds to that of said upper and lower faces of the slide;

[0017] the upper face and the lower face of the slide have the shape of a protruding V with two facets;

[0018] a plate is attached to the outer face of the door and has two protruding flanks which extend in a plane perpendicular to the axis Z-Z' of the pivot, each flank being perforated with an aperture, the pivot having a blind hole at each of its two ends and a shoulder screw being screwed into each blind hole through the aperture provided in the flank, so as to allow the pivoting of the door around the pivot;

[0019] said door is provided with blocking means preventing its pivoting around the pivot with respect to said slide and holding it in a position where it is perpendicular to the displacement axis of said slide;

[0020] the slide is provided at its front end with a port passing through it from side to side, the door having at its periphery, on its face situated facing the pivot, a blind hole and said blocking means comprising a removable pin configured to be able to be inserted through said port, into said blind hole, thus blocking the pivoting movement of the door with respect to the slide;

[0021] the door is provided with at least one handle on its outer face;

PRESENTATION OF THE FIGURES

[0022] Other features and advantages of the invention will appear from the description which will now be made, with reference to the appended drawings which represent, indicatively but without limitation, a possible embodiment of it.

[0023] In these drawings:

[0024] FIG. **1** is a perspective view of an exemplary embodiment of the heat exchanger conforming to the invention,

[0025] FIGS. **2** to **5** are perspective views of the exchanger of FIG. **1**, showing the opening and closing kinematics of the door of this exchanger, and

[0026] FIG. 6 is a vertical section view of a portion of the exchanger, taken along the section plane represented by line VI-VI in FIG. 1.

DETAILED DESCRIPTION

[0027] Referring back to FIG. 1, it can be seen that the heat exchanger 1 conforming to the invention comprises a gas-tight shell 2. This rests for example on legs 20.

[0028] In the rest of the description and of the claims, references to the terms "horizontal" or vertical will be taken into consideration with respect to the position of the exchanger 1 in FIGS. 1 to 5.

[0029] The shell 2 contains a heat exchange device 3 allowing a fluid, for example cold water, to be heated.

[0030] In the figures, reference symbols 21 and 22 correspond to the inlet and outlet apertures of the device 3 of the heat exchanger.

[0031] The shape of the shell 2 is immaterial (indifferent). It has a longitudinal axis X-X'. In the example shown in the figures, this shell 2 is cylindrical. It also has a burnt gas discharge sleeve, not visible in the figures.

[0032] The shell 2 has a face 23 which delimits an opening 230 for access to the interior of said shell. By convention, the end of the shell 2 situated in proximity to the face 23 is called the front end 24 and its opposite end, the rear end 25.

[0033] The shell 2 also comprises a door 5 designed to close the opening 230 provided in the face 23.

[0034] A burner 4 is attached to the central portion of the door, on its inner face 51, from which it protrudes. The inner face 51 of the door 5 of the shell 2 is the face oriented towards the inside of the shell 2 when the door 5 is closed. Thus, when the door 5 is closed, the burner 4 is positioned in proximity to the heat exchange device 3. The shell 2 delimits a combustion chamber 30 (see FIGS. 4 and 5).

[0035] Advantageously, but not compulsorily, the burner 4 is cylindrical, with longitudinal axis X1-X'1. Also preferably, this longitudinal axis X1-X1 is coaxial with the longitudinal axis X-X' of the shell 2.

[0036] The burner 4 preferably uses gas or fuel oil.

[0037] The combustion gases generated by this burner 4 accomplish the heating of the fluid contained in the heat exchange devices 3.

[0038] As can be seen in FIG. 3 for example, the outer face 52 of the door 5 is preferably connected to a sleeve 53 for supplying a combustible gas mixture (gas, fuel/air or fuel oil/air for example), and the transfer of this mixture to the burner 4 is accomplished through an appropriate opening provided in the door 5.

[0039] As is more clearly visible in FIGS. 4 and 5, the zone of the inner face 51 of the door 5 which surrounds the burner 4 is advantageously covered with a heat-resisting and thermally insulating material 54 and a seal 55.

[0040] The door 5 is mounted pivotally around a pivot 6, itself supported by and attached to the end, or substantially to the end of a slide 7. Said slide 7 is guided and mounted sliding with respect to the guide means 8 provided on the outer face of the shell 2.

[0041] According to one possible embodiment, the door 5 is equipped with a plate 56 attached, for example by means of screws 560, to the outer face 52 of the door. This plate could also be an integral part of the door, if the latter were cast for example.

[0042] The slide 7 is a planar rectilinear strip of low thickness having, as can be seen in FIG. 1, an exterior vertical face 70, an upper face 71, an opposite lower face 72, a rear end 73 and a front end 74.

[0043] Preferably, the upper face 71 and the lower face 72 each have in cross-section, a V shape of which the point protrudes toward the outside; in other words, they have two facets 711, 712, respectively 721, 722.

[0044] As appears more clearly on the section view of FIG. 6, the pivot 6 is attached, for example by welding, through the front end 74 of the slide 7.

[0045] The pivot 6 extends along a vertical axis Z-Z' perpendicular to the longitudinal axis X2-X'2 of the slide 7.

[0046] The pivot 6 has a blind tapped hole 61 at each of its two ends.

[0047] The two sides, top and bottom, of the plate 56 are curved horizontally forward to form two flanks 561 extending in a plane perpendicular to the axis Z-Z'. Each flank 561 is perforated with an aperture 5610. The two apertures 5610 are aligned vertically and each leads into a position facing one of the blind holes 61 of the pivot 6.

[0048] A shoulder screw 562 is screwed into each blind hole 61 through an aperture 5610, with a clearance allowing the pivoting of the plate 56 and therefore of the door 5 to which it is attached, around the pivot 6. This pivoting can be accomplished through an angle of at least 180°.

[0049] According to a possible embodiment of the invention, the guide means 8 comprises a plate 80 and four rollers, respectively two rear 81 and front 82 upper rollers and two front 83 and rear 84 lower rollers (see FIGS. 1 and 6).

[0050] The plate 80 is attached, by welding for example, to the exterior face of the shell 2. It has a flat exterior face 800.

[0051] The rotating rollers 81 to 84 are mounted as idlers around axes of rotation, respectively 810, 820, 830 and 840, themselves attached to the exterior face 800 of said plate 80.

[0052] The axes 810 to 840 are orthogonal to the longitudinal axis X-X' of the shell 2.

[0053] The rollers 81 to 84 are for example rollers in the shape of twin wheels (diabolo shape) having at their periphery an annular groove respectively 811, 821, 831 and 841, the shape of which cooperates with that of the upper 71 and lower 72 surfaces of the slide 7. The two-faceted shape of these faces facilitates self-centering of the slide 7 with respect to the rollers.

[0054] The slide 7 is thus guided axially by the guide means 8 along a displacement axis X2-X'2, which is congruent with the longitudinal axis X2-X'2 of the slide 7 and which is moreover parallel to the longitudinal axis X-X' of the shell 2.

[0055] Advantageously, two of the diagonally opposite rollers, here for example the rollers 81 and 83, are disposed on the plate 80 so as to be aligned on the slide 7, and to facilitate their rolling on the latter. Conversely, the two other rollers situated on the opposite diagonal, here for example the rollers 82 and 84, are disposed on the plate 80 so as to have a slight clearance with respect to the slide 7, which allows movement of the slide 7 but prevents jamming caused by dimensional dispersion or the geometry and the assembly of the different parts of the system.

[0056] The slide 7 is thus guided axially along the displacement axis X2-X'2 and this, in the two opposite directions, so that it can move along a given path, between an extreme position called "retracted," illustrated in FIG. 2, in which its rear end 73 is near the rear end 25 of the shell 2 and an opposite extreme position called "extended," shown in FIGS. **3** and **4**, in which its rear end **73** is moved in the direction of the guide means **8**.

[0057] Advantageously, the rear end **73** of the slide **7** has a rear stop, shown here in the shape of two protruding fingers **75** extending parallel to the axis Z-Z' of the pivot **6**. This stop **75** limits the forward travel of the slide **7** and avoids its complete disengagement from the guide means **8** when it is located in the "extended" position.

[0058] The slide **7** is dimensioned and guided so that its travel along the axis X2-X'2 is greater than the length of the burner **4**, so as to allow the total extraction of this burner from the shell **2**.

[0059] Finally, it will be noted that the slide **7** cannot slide out of the rollers **81** to **84** to the rear due to the presence of the pivot **6** which serves as a stop.

[0060] Also advantageously, the front end **74** of the slide **7** is provided with a port **76** perpendicular to the axis X2-X2 and orthogonal to the axis Z-Z' of the pivot **6**. This port **76** passes through the slide **7** from side to side. In addition, the door **5** has at its periphery, on its face situated facing the pivot **6**, a blind hole (not visible in the figures) situated in the continuation of the port **76** when the door **5** is in the closed position. A removable pin **77** can be inserted into the port **76** and into the blind hole of the door **5** facing the port **76** so as to hold the door **5** blocked in the position perpendicular to the slide **7** during the movement of the latter.

[0061] In the closed position of the door **5**, gas-tightness must be ensured. To this end, the door **5** is advantageously screwed to the face **23**.

[0062] Advantageously, the door **5** is also provided with one or more handle(s) **58** allowing its handling, which are attached to its outer face **52**. The kinematics of opening and closure of the door **5** will now be described in connection with FIGS. **2** to **5**.

[0063] FIG. **2** shows the operating position of the heat exchanger **1**, in which the burner **4** is active and heats the fluid circulating in the heat exchange device **3**. In this position, the door **5** is in the closed position, it closes the access opening **230**, and the slide **7** is in the retracted position.

[0064] When the operator wishes to carry out a maintenance operation, he stops the operation of the burner **4**. He can then, by pulling on the handles **58**, cause the slide **7** to slide until it reaches its extended position, shown in FIG. **3**. The slide **7** is then moved until its end-of-travel stop **75** comes into abutment against the rollers **81** and **84**. The pin **77** is still in place, so that the door **5** remains perpendicular to the slide **7**. The door **5** then is then located in a position called "space-apart" ("separated") in which it is moved away, i.e. separated from the access opening **230**.

[0065] In addition, the length of the slide **7** and the positioning of its rear stop **75** having been adapted based on the size of the burner **4**, this is located completely outside the firebox **30**.

[0066] The operator then withdraws the pin **77** so as to allow the pivoting movement of the door **5**, toward the front of the exchanger **1**, around the pivot **6**, until the latter is brought to a so-called "returned" position shown in FIG. **4**.

[0067] In this returned position, the door **5** has pivoted by at least 180°. The burner **4** being previously completely withdrawn from the shell **2**, it does not risk entering into collision with the exchange device **3**.

[0068] Finally, the operator can also push back the door **5**, so as to bring the slide **7** into its retracted position and thus achieve the disposition shown in FIG. **5**. In this latter position, access to the combustion chamber **30** is total, which facilitates maintenance operations. The same is true for the burner **4** which, when the door **5** has pivoted 180°, is completely accessible.

[0069] When the maintenance operations are finished, the operator can then move the door **5** forward, so as to bring the slide **7** into its extended position (FIG. **4**), then make the door **5** pivot 180° to bring it back into the spaced-apart position of FIG. **3**, block the pin **77** in the port **76**, push the door **5** and the slide **7** back so as to bring the slide into its retracted position and the door **5** into its closed position.

[0070] Generally, the invention is particularly well suited for a burner **4** of which the size (dimensions in length and in width) is such that the door **5** could not be opened without risk of damaging the device **3** if it was provided with a simple hinge as in the prior art.

1. A heat exchanger (**1**) comprising a gas-tight shell (**2**) containing a heat exchange device (**3**) and delimiting a combustion chamber (**30**), said shell (**2**) being provided with an access opening (**230**) and with a door (**5**) suitable for being able to close said access opening, said door (**5**) being provided with a burner (**4**), particularly for gas or fuel oil, protruding from its inner face (**51**), characterized in that said door (**5**) is mounted pivotally around a pivot (**6**) attached to the so-called "front" end (**74**) of a slide (**7**), or substantially to this front end, in that said shell (**2**) is provided on its exterior surface with guide means (**8**) which allow said slide (**7**) to be guided axially along a displacement axis X2-X'2 which extends parallel to the longitudinal axis X-X' of said shell (**2**) and in that the pivot (**6**) extends along an axis Z-Z' perpendicular to said displacement axis X2-X'2, and in that the travel of said slide (**7**) is greater than the length of the burner (**4**), so that said door (**5**) can be moved from a closed position, in which it closes the access opening (**230**) of said shell (**2**), to a so-called "spaced-apart" position, in which it is moved away from this access opening (**230**) and in which the burner (**4**) is located outside the shell (**2**), and said door (**5**) being able to pivot around the pivot (**6**) when it is located in said "spaced-apart" position.

2. The heat exchanger according to claim **1**, characterized in that the door (**5**) can pivot around the pivot (**6**) at an angle of at least 180°.

3. The heat exchanger according to claim **1** or **2**, characterized in that the slide (**7**) is provided with an end-of-travel stop (**75**) which prevents it from leaving the guide means (**8**).

4. The heat exchanger according to one of the preceding claims, characterized in that the slide (**7**) is a strip having an upper face (**71**) and a lower face (**72**) and in that the guide means (**8**) comprise two upper rotating rollers (**81**, **82**) and two lower rotating rollers (**83**, **84**) in the shape of twin wheels, mounted as idlers, provided with a groove (**810**, **820**, **830**, **840**), the profile of which corresponds to that of said upper (**71**) and lower (**72**) faces of the slide.

5. The heat exchanger according to claim **4**, characterized in that the upper face (**71**) and the lower face (**72**) of the slide have the shape of a protruding V with two facets (**711**, **712**, **721**, **722**).

6. The heat exchanger according to one of the preceding claims, characterized in that a plate (**56**) is attached to the outer face (**52**) of the door (**5**) and has two protruding flanks (**561**) which extend in a plane perpendicular to the axis Z-Z' of the pivot (**6**), in that each flank (**561**) is perforated with an aperture (**5610**), in that the pivot (**6**) has a blind hole (**61**) at each of its two ends and in that a shoulder screw (**562**) is screwed into each blind hole (**61**) through the aperture (**5610**) provided in the flank, so as to allow the pivoting of the door (**5**) around the pivot (**6**).

7. The heat exchanger according to one of the preceding claims, characterized in that said door (**5**) is provided with blocking means (**77**) preventing its pivoting around the pivot (**6**) with respect to said slide (**7**) and holding it in a position where it is perpendicular to the displacement axis (**X2-X'2**) of said slide (**7**).

8. The heat exchanger according to claim **7**, characterized in that the slide (**7**) is provided at its front end with a port (**76**) passing through it from side to side, in that the door (**5**) has at its periphery, on its face situated facing the pivot (**6**), a blind hole and in that said blocking means comprise a removable pin (**77**) configured to be able to be inserted through said port (**76**), into said blind hole, thus blocking the pivoting movement of the door (**5**) with respect to the slide (**7**).

9. The heat exchanger according to one of the preceding claims, characterized in that the door (**5**) is provided with at least one handle (**58**) on its outer face (**52**).

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END OF REPORT