-

The modernization led to following results

- variable temperature control in axial direction
- use of energy before: 6,70 € per operating hour
  after: 1,55 € per operating hour
- fully automated

10 Conclusion

In consideration of the previously talked about impulse firing methods different problems occurred over the years. Therefore new methods and technologies had to be developed. The steadily modernization led to a modular structured system where specific software components can be used for individual problems.
The latest development, the BBM-impulse fan burner including Lambda-automatic is based on automated impulses inside the combustion chamber whereby optimum product quality, energy efficiency and smallest possible pollution is the result.

The rapid cooling takes place via the fan-firing unit at temperature depending operation, whereby the cooling peripheral unit is not applicable. At failure of a decentralized fan, which supplies several burners, a complete operation stoppage would be the result and that could lead to cost-intense product damage. However at failure of 1 impulse fan burner (for systems with for example 6 burners) no impact would result on the product and therefore the firing process can be finished and the malfunction fan burner can easily be replaced during the process.

9.4. The impulse fan burner with Lamda-automatic at drying technology

Drying plants (rotary kiln dryer, chamber dryer etc.) mostly have complex air-heating systems, which are mostly equipped with indirect air heating to avoid influences through waste gas at the material to be dried.
Decentralized air heaters as from 600 kw are very cost intense energy sources. Additionally they demand complex air supply systems (like warm air channel including complete periphery etc.). By the use of impulse fan burners with Lambda – automatic the emission values are so low that the dry-atmosphere can be directly fired. Therefore gas exhaust takes place indirectly over the exhaust air and wet-air duct.The performance of 2 continuous flow chamber driers for the poly-urethane industry (figure 17), showed optimal values in all relevant areas.
Through the direct heating in the drying chamber, the normally needed combustor for indirect heating is not needed. In the drying chamber the exhaust gas is being collected via the flow circulation of the drying atmosphere.
The exhaust gas evacuation is being done via the cyclical exchange of the saturated wet-air.

Through the optimal combustion with the Lambda-automatic minimal emission values result,whereby drying systems can be run in a temperature area of 50-180°C.


(figure 18)


(figure 18.1)


(figure 18.2)


(figure 18.3)


(figure 18.4)

Another example for the use of impulse fan burners is the reconstruction of a rotary dryer for the production of ceramic micro pearls. (figure 18)


(figure 19)


(figure 19.1)


(figure 19.2)

The following points were the reconstruction objectives:

- lowering the energy costs
- conversion with BBM- impulse fan burners for temperature distribution in axial rotary tube depth via variable band-width modulation
- conversion of liquid gas to natural gas

At conventional impulse operation the flame output is being controlled by regulating the impulse frequency.
The required burner output is being achieved by changing the gas volume. The necessary air volume was so far configured consistent. The combustion air in the area 90-100% is set consistent to eliminate oxidizing firing and therefore a relative complete combustion takes place and acceptable emission values are being achieved (lambda 1,0-1,4).

At consistent set combustion air volume following disadvantages result:

- by reaching the nominal temperature the impulse frequency is being reduced. However the air volume remains constant, which results in an unwanted cooling effect via air overflow in the combustion chamber. The impulse controller try's to compensate this temperature drop whereby the control receives a swinging performance, which negatively influences the temperature technical efficiency.

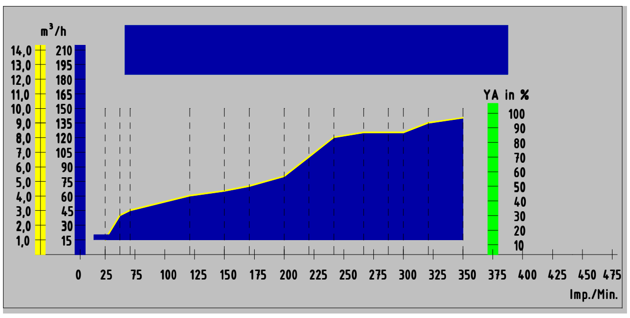
- during the combustion with high air overflow negative or illegitimate emission values result.

Conclusion:
Only in the top power range of the burner an optimal energy and emission technical combustion process happens.

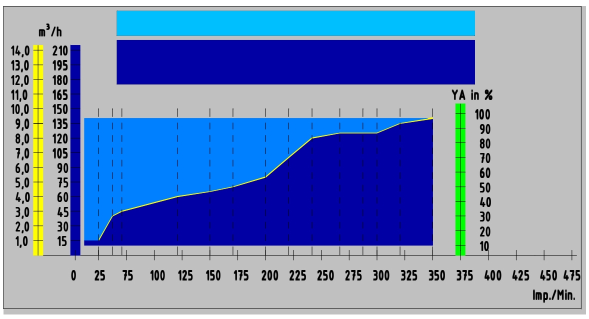
9.2. The "Lambda –automatic" at impulse operated fan burners

The energy technical efficiency in connection with minimal emission load on the environment via combustion exhaust gas stands in a direct relation of the combustion air ratio and is dependent on it. The combustion air ratio places the actual, for the combustion available air mass (mL,tats) in relation to the least necessary stoichiometric air mass (mL,st), which is necessary for a complete combustion. To reach a complete combustion with an impulse burner in the power range 0-600imp/min, it is necessary to automatically adjust the ratio fuel with the ratio combustion air to the continuously changing impulse frequency. By including the physical parameter gas pressure (PE) at the impulse valve, in dependency of the valve opening time (ti) and the temperature depending impulse frequency (0-600imp/min), a by the software impulse control calculated gas flow-rate at the burner results. The impulse control constantly analyses the gas volume and changes the air-flow via the speed control of the air-fan for a optimal combustion at the burner. Because of that process a full combustion is given over the total impulse frequency range.

(figure ???)



(figure ???)



(figure ???)

9.3. Energy efficiency

The energy savings with impulse firing at chamber kilns, shuttle kilns, tunnel kilns etc. is about 18-25%, provided that the oven corpus is constructively good and operational characteristics are normal.
With modification of existing impulse fired systems with Lambda-automatic (figure 16a) further energy savings are being achieved due to the complete combustion. Furthermore better emission values result, which meet the legal requirements.
Due to only software integration, energy efficiency increases from 25% up to 40% at the modernized chamber kiln. Different tests with varied oven loads proved that the energy savings remained constant. All of the media distribution components (such as pipeline construction, ventilators, measuring devices etc.) are not applicable when reconstructing firing facilities with impulse fan firing technology. This can save up to 15% of the firing facilities price.

Usually most of the tunnel ovens have an integrated tunnel oven vehicular trace, because of this all positions of the oven vehicles and therefore also the respective fuel information in the burning conduit of the PLC control are known. This tunnel oven vehicular information is evaluated in the PLC control and the necessary control parameters (BBM- modulation times) are automatically transferred to every individual burning aggregate.
Because of the fully automated assimilation of the burning parameters, the entire firing facility automatically converts in every area of the burning zones (pre fire and main fire) based on the saved formulation data in combination with the vehicle positions.

8.2 The „intelligent" band-width modulation over temperature differences in the oven cross-section [IBBM]

The temperature dependent band-width modulation works independently from the necessary parameter standards which are manually or automatically transferred to the software controllers to influence the length of the burning gas rays.
The alteration/ assimilation of the Impulse length parameter (ti1;ti2;ti3) [figure12 and 12.1] from the Impulse valve occurs depending on the firing zone through three temperatures (up, middle, down) which are apprehended in the height cross-section. The sensing element (sensor) which is arranged in the middle, provides the control component with the actual value, to implement the temperature regulation with the power outlay (impulse frequency). In the PLC Control the temperature information of the upper and lower combustion chamber cross-section are compared to deviations with the middle cross-section temperature (reference). In the case of deviations of the middle reference temperature the impulse length parameters (ti1, ti2, ti3) are influenced dependent on the calculated temperature deviations by an intelligent functional component which communicates with the modulation level, therefore a targeted energy dislocation through burning gas ray alterations (BGS1;BGS2;BGS3) [figure 13] in the combustion chamber takes place.

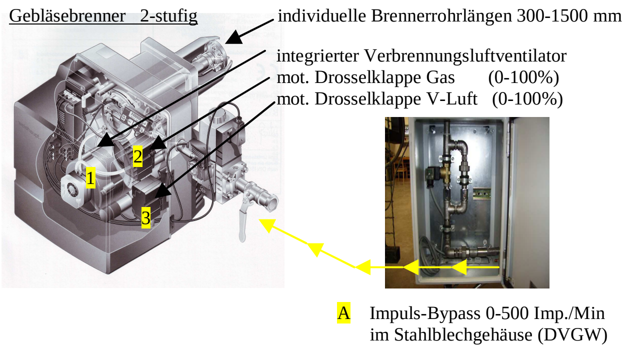
9 New developments

The earlier described impulse firing technologies have been established by means of very good operating characteristics, economization and quality optimization and are still being used nowadays in the c eramic firing industries. Conditional on permanent increasing environmental guidelines (TaLuft and BlmSchG) further innovative developments are necessary to optimize the combustion process.
The following listed points are the basis for innovative and cost-effective impulse firing technology, which can be applied in all areas of the industry.

-optimization of energy efficiency
-reduction of emission values (due to optimization of the firing process)
-reduction of the necessary primary energy
-savings of cost-intensive control units

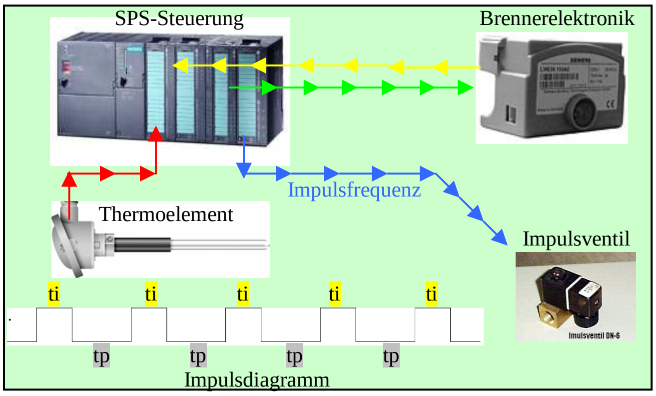
9.1 The impulse operated fan burner

The two-stage fan burner (figure 14) has an independent combustion air supply and due to 2 integrated motor-driven throttles it can be applied for gas and combustion air modulating. Throttle 1 and 2 can electrically be controlled independent of each other. The activation of the gas and air throttle takes place process dependent in the working area 0-100% via the PLC control unit, whereby the necessary gas and air volume is being added in the perfect rate at any stage into the combustion process and therefore creates an ideal combustion.



(figure 14)

By integrating the impulse bypass periphery the gas impulse burner can be used with symmetrical impulse operation or with band-width modulation.
Different burner tube material and length are available for different mounting situations.
At conventional impulse operation the flame output is being controlled by regulating the impulse frequency.
Different burner tube material and length are available for different mounting situations.



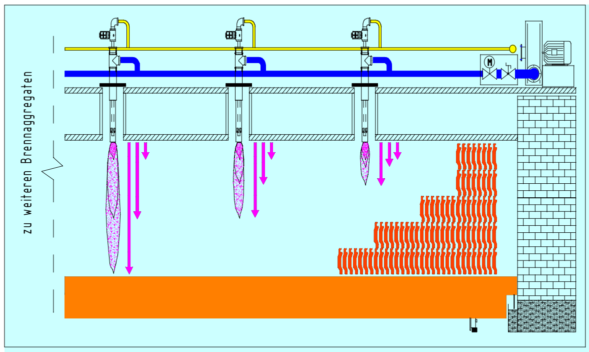
(figure 10)

The variable break time tp is shortened or extended by deviations of the temperature difference Delta T dependent on the PID parameter level, whereby via the variable automated impulse frequency the necessary fuel inlet results through the fireplace (figure 11).
The bigger the combustion chamber of a kiln plant, the bigger the temperature difference in the combustion chamber atmosphere at the highs cross-section, therefore no equal firing can take place. With only one solid valve reaction time ti, this problem couldn't be solved satisfying.

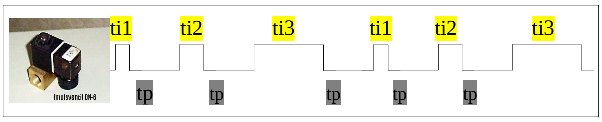
Since the practical experience showed that a large number of tunnel kilns are working with a temperature difference of up to 80° and therefore the operator had to accept a quality decrease of his product. Because of that, the band-width modulation (BBM) was developed.

7.2 The asymmetric impulse control method with band-width modulation (BBM)

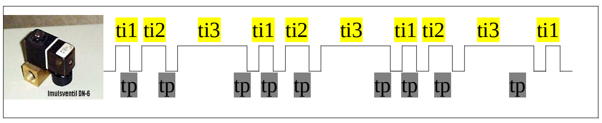
To compensate the differences in temperature in the height cross-section, the earlier described impulse firing method was further modified, by inserting additional cyclically automated opening time parameters into the Software control structure (ti1; ti2; ti3) [figure 13 and 13.1] The Parameter places (tn1; tn2; tn3) are freely parametrizable, therefore through entry of different time constants the ring cyclical treatment produces three different fuel gas jet expansions, dependent on the temperature-dependent calculation of the valve break time. The software based impulse control component, possesses a modularly built structure (recording of temperatures, PID level, power level (Imp/Min.); BBM modulation level). This Construction in connection with the Individual impulse valves at every firing point enables, by firing group constructions with several firing points, to select every individual firing unit/aggregate over an independent impulse software controller, therefore every burner can adequate to requirements be individually adjusted. [figure 14]. Due to the software based Impulse control component [BBM band-width modulation] a temperature equalization of almost 100 % (homogenous firing atmosphere) in the entire combustion chamber is achievable.



(figure 13)



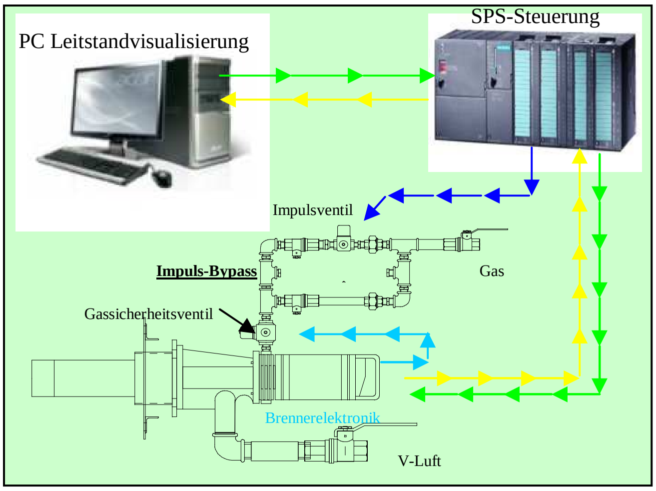
(figure 12)



(figure 12.1)

8.1 The „intelligent" band-width modulation over vehicular trace [IBBM]

Oven facilities which are often loaded with changing fuels, combined fuels or different fuel weights need, depending on the product charge that need to be burned and product formats, different parameter standards, which are automatically and product-specific transferred to the Burn zone controllers, to achieve an ideal burn result in all product groups.



(figure 8)

This power state of the burner (fire load operated) requires a minimal flame power, which has no temperature technical impact on the firing process, but still features a solid firing behavior to connect to impulse firing, whereby the control technical process takes place (figure 8).

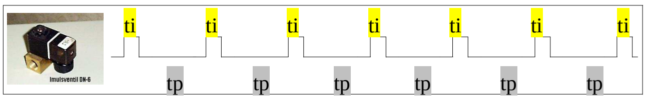
6. The impulse-bypass (construction and function)

Considering all the detected problems for impulse operation of self-activating burners, 1994 the impulse-bypass was developed. The impulse-bypass (figure 9) is split into 3 bypass sections A, B, C, whereby with activation of the integrated magnetic valve 4 and 7, different physical fuel ways emerge. The necessary fuel throughput of single firing ways is individually made by means of the fine dosing devices 5 and 6. With demand of the burner, gas safety valve 7 opens and the fire load operation does built up via the bypass section C.
The ignition flame stability is being controlled via a automatic burner control (DVGW). The S7 control is signaled after flame stability and stable flame ionization. Bypass sector A initiates the impulse operation.
The by the control calculated impulse frequency 0-500 imp/min. controls the fuel feed via the impulse valve 4. The metrological and control technical activation results via specific software modules on basis of Simatic S5, S7 and Vipa S7 systems.

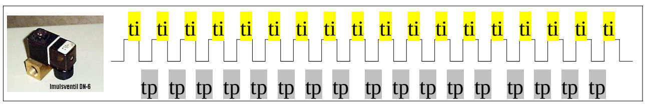
7. The different impulse control methods

The software based impulse control technology doesn't need conventional c omponents, like temperature controller, measuring transducers, coupling elements etc., because the complete data logging is done via the PLC control. Via the modular built-on control software, all input data is metrological and control technically evaluated and temperature technically calculated.
The control of the burners (ionization monitoring, release and impulse frequency) results directly via the output-side (figure 11).
Due to uncomplicated expansion possibilities of the PLC hard- and software structure, it is easily possible to convert every firing system cost-efficiently from complete reconstructions or section wise conversions.

7.1. The symmetric impulse control method

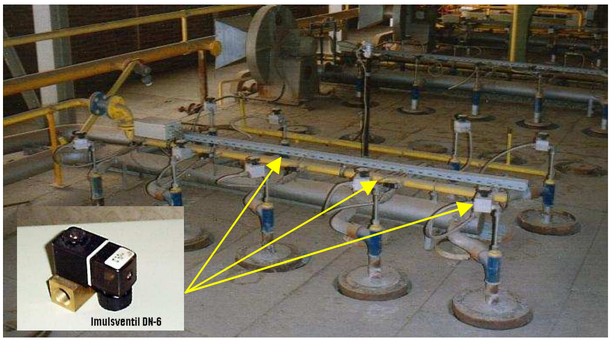


(figure 11)



(figure 11.1)

The valve loop at (Ti) provokes a from the fuel medium pressure depended fuel gas jet expansion. Dependently of the flame length, resulting from the opening cycle, the heat energy resulting from it is transported to an always continuous combustion chamber range for each impulse. The burner output is calculated via the impulse control module by means of evaluation of the nominal/actual temperature. The impulse frequency controls the performance from 0-100% (0-500 imp/min.) through the automated impact of the valve reaction time tp (variable pause time).



A conversion from a firing zone with 10 burners to the new single impulse operation per firing point (figure 6), results in a 50% investment savings compared to the impulse zone valve (figure 4). Caused by the small power consumption of the impulse valve of max. (0,37 A), the electronic control can take place directly via the SPS output side and therefore further savings can be made, because of the omission of coupler components and less wiring expenditure.

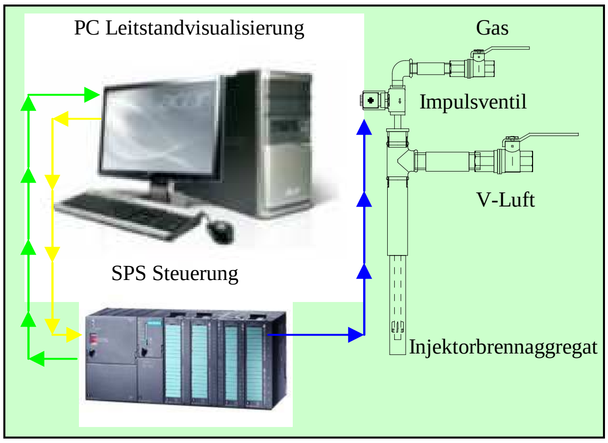
(figure 6)

4.1. Advantages when using single impulse valves

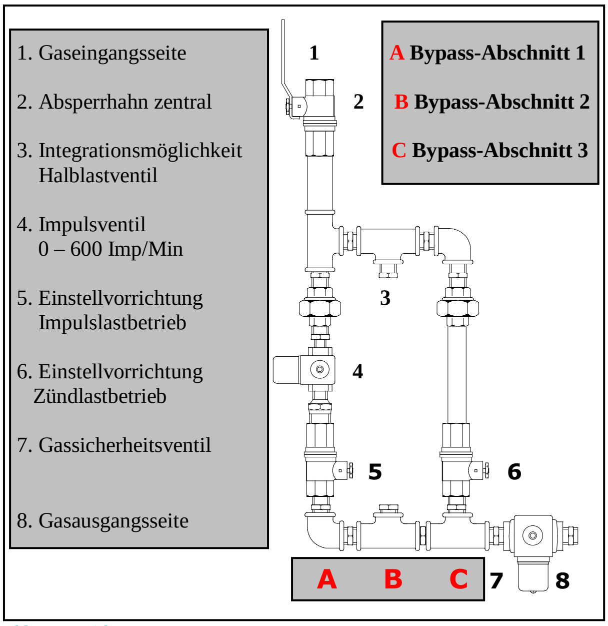
- Direct control of the fuel valve from the PLC-Digital component through the small power consumption of max. (0,37 A)
- If a failure on 1 fuel valve occurs, the remaining valves in the firing zone aren't affected.
- Independent adjustment settings of the fuel throughputs for each firing point.
- Unrestricted flexibility of the controlling possibilities of single burners in a firing zone (Stokehole loading).
- Parallel operation
- Sequence control loop-cyclically
- Asymmetric control
- Control with various impulse lengths

5. The high speed ignition burner with impulse control for use below 650°

The impulse firing systems talked about before occurred only in the injector burner sector without igniter, whereby there was a limit for the impulse firing below the ignition temperature of 650° (figure 7). These circumstances forced another improvement, which made it possible to use high-speed burners with ignition and flame control to work in the pre fire and heating-up area with turbulences underneath the ignition temperature and thus creating a homogeneous combustion atmosphere in all areas in the oven.



(figure 7)



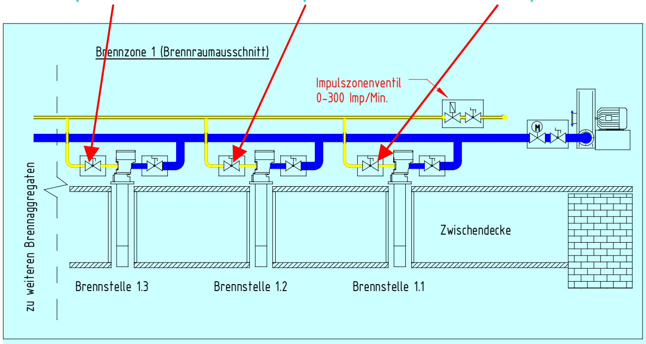
(figure 9)

The high-speed burner couldn't be used like the injector burner where the fuel mix is ignited with entry in the firing zone, since the time dependent progress, ionization set-up and control of the safety valve (DVGW- guidelines) wasn't possible with impulse firing. Under adherence of the DVGW guide lines we realized very fast that the burner needs to be started in the least possible power range of ca. 10% to achieve the ionization control (flame stability).

2. Disadvantages of conventionell impuls firing systems

The earlier described impuls firing systems are very costly and time consuming firing installations ,by what the use of that impuls firing technology was established with mainly productions for sophisticated ceramic products. The fuel feed of the burners is another disadvantage when zoning (figure 2). Because of the conditional supplies assembley of the impuls zone valve, there are up to 10 burners in one firing group powered. Due to different pipeline length to the burners there are different pressure decreases to each of the burner lances and therefore a disadvantageous flow behavior can appear. Those unwanted pressure and flow behaviors need to be compensated with different burner adjustments, which doesn't lead to satisfying results (figure 3).

Kv-expansionline 3 Kv-expansionline 2 Kv-expansionline 1



(figure 3)

3. The renaissance of the impulse firing technology with latest valve technique for industrial firing at SPS based systems

1992 impulse combustion at SPS basis with Simatic S5 was used for the 1st time in Minden with the company Dachziegelwerke Heisterholz. The ceiling combustion was grouped in firing zones with each 10 injector burners and equipped with a impulse zone valve 0-300 imp/min (figure 4). The complete data logging is realized with the SIMATIC PLC control system. The control software evaluates the current temperature situation and calculates the necessary impulse frequency. Through the change to this system, energy savings of 25% resulted.

(figure 4)

Despite the successes until to that point, the problem of the pressure loss was caused by the zone valve. The fuel way to each of the burners in a firing zone was also still different, which led to the reflection to develop an electro magnetic micro valve with a high switching frequency.

4. The fuel valve

The impulse valve is the electro magnetic heart of the impulse firing technologies and is exposed to extreme mechanical stress. To eliminate the earlier described disadvantages of the zone valves, a cooperation with the company Danfoss took place in 1993, to develop a micro valve for high frequent operations.

<u>The technical features where identified as follows:</u>

Smallest of structural engineering
Wear-free material components
High frequency operation conditions 0-1000 imp/min.
Minimal power take < 0,4 amps.
Operating voltage 24 V DC

(figure 5)

After a short development time the special valve went into production and complied all the necessary requirements (figure 5). The first pilot combustion with the new special valve was 1st used and tested at the tunnel kiln 1 in Minden for the company Dachziegelwerke Heisterholz.

Impuls firing technology with integrated “LAMBDA- automatic”

Ralph Kiem (49) electrician developed 1992 the BBM impulse burning system on PLC based technology. After successful applications at ceramic firing equipment, R. Kiem optimized his product and developed the worldwide first fan-impulse-burner with 0-500 imp./min and with integrated LAMBDA – automatic for energy

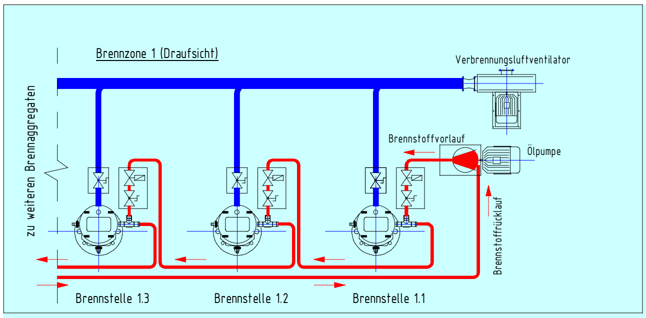
Outline

During the last few years, impulse burning technology to optimise the combustion quality and energy efficiency on PLC technique in the ceramic industry, has gained in importance. To keep up with the steadily increasing environmental clause (TAluft / BLmSchG) in the industry further developments of field-tested systems are needed.
The impulse-fan-burner with automatic combustion air adjustment is the answear to flexibel automated turbulences in the firing atmosphere amongst compliance with the emission guidlines by law and with additional energie savings at 20% compared to any impulse burning systems up to now.

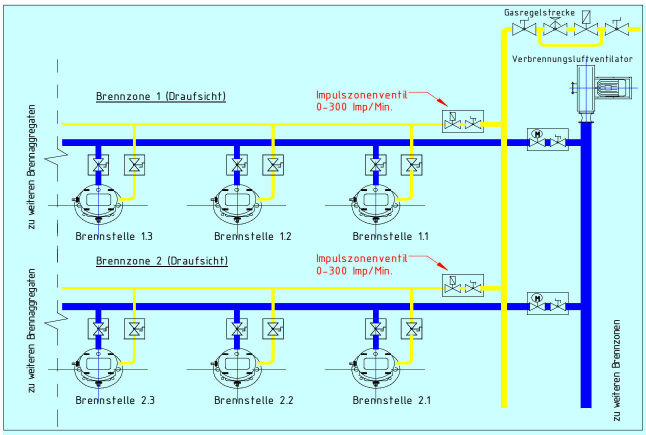
1. Introduction

The application of impulse burning in the ceramic combustion started 1958. The combustion was mainly done with light or heavy oil. The functional construction (figure 1) comprises a fuel loop with a central fuel pump for the direct supplying of the burners. The combustion air was added to the firing process via burner lances. The fue l metering was done with electromagnetic activation of upstream magnetic valves via cyclical impulses from 0-250 imp/min, whereby the fuel in the burner lances was mixed with the combustion air and with exit at the lances in the combustion chamber ignited at a temperature <650°. Due to changes of the impulse frequency level the burner controls the fuel feed and therby the burner output.
The structure of impulse firing was changed with the availability of natural gas. The impulse controlled fuel feed was supplied via a central impulse valve per firing zone, with 6 to 8 burners over one fuel distributor line. The temperature control is being realised with the impulse frequency level like with the older oil firing systems.
The fuel feed on impulse basis creates inside the combustion chamber atmosphere, depending on the frequency level or impuls lenght, slightest explosions, whereby the firing material is exposed to strong turbulences. The turbulence rise inside the combustion chamber causes an ideale temperature technical circulation of the firing material and a absolute homogeneous firing atmosphere.

By the use of the above mentioned impulse firing technology, energie savings at around 20% are being achieved and a higher quality for the firing materials. Thyristor modules are used to activate the high frequent impulse valves with (6 A) power consumption. Because of changing the firing system to impulse operating, we achieved energie savings of 25% aswell as higher quality of the firing materials.



(figure 1)



(figure 2)