Приборы и оборудование

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Multi-Fuel Burner Systems for Industrial Applications

Multi-fuel firing systems are used in several industrial processes such as in power stations, drying mills and metallurgical plants as well as in rotary kiln systems, industrial boilers, cogeneration plants and various thermal process factories. Such systems should being not only able to utilize different fuel types, but also to respond flexible due to changing in fuel compositions and qualities. In particular the ignition, stability and pollutant problems must be taken into account. That means that these systems should fulfill the operational parameters and ecological target according to German Technical Instructions on Air Quality Control TA Luft 2002. The Operation of these so called multi fuels systems is determined on the one hand by the conditions of the start-up procedure (e. g. drying of the refractory material, creation of the necessary operating environment) and on the other hand by the process-related requirements, fluctuating commodity prices, unstable fuel supplies and the use of internally resulting production scrap. In this paper two multi-fuel burner systems are selected from the extensive Brinkman's production program to be shown in details. These are combined combustion systems for «pulverized coal-gas» and «pulverized coal-oil», respectively. *Bibl. 9, Fig. 6, Table 1.*

Key words: coal-gas burner, coal-oil burner, environmental pollution, pulverized fuel, TA Luft 2002, burner capacity (flow rate), operational chart.

Introduction

The Brinkmann Industrielle Feuerungssysteme GmbH (BIFS) possesses a solid basis in research and development, engineering, construction, manufacturing and operating of efficient combustion systems for use in different industrial applications. Since 1883 BIFS develops, builds and delivers burner and lance systems for use in energy-intensive processes such as coal gasification to produce synthetic gas for combined cycle applications, petrochemical production, copper and steel melting as well as lime production and treatment, hot gas generation and secondary metallurgy.

Depending on the specific process demands of industrial application, the multi fuel combustion systems have to work stable and safe under required special operating conditions. Besides being able to utilize different fuel types, they should also respond flexible due to changing in fuel compositions and qualities. In particular the ignition, stability and pollutant problems must be taken into account. That means that these systems should fulfill the operational parameters and ecological target (emission limit values for NO_x, CO, sulfur oxide and dust values) according to German Technical Instructions on Air Quality Control TA Luft 2002 [1] for the industrial processes dealing with. The limit values for NO_x and CO emission according mentioned TA Luft are given in the following table for industrial plants with burner capacities up to 50 MW_{th} (Table):

Pollutants	Fuels		
	light oil emission, 3 % O_2	Gases, 3 % O_2	Coal & Coke, 7 % O_2
NO_x, mg/m^3	180–250	100–150	250–500*
CO, mg/m^3	80	50–80	150
Dust, mg/m^3	50	5 for natural gas 10 other gases	20–100*

* Depending on thermal load

While to stabilize the combustion process of multi fuels burners mainly swirl geometry at the burner head is used [2, 3], the air staging technique [4, 5] in combination with internal or external flue gas recirculation led to low NO_x emission values [4–7]. Although, through these measures NO_x values achieved are lower than TA Luft limits, CO emission values especially in part load operation mode and during switching operation mode from one fuel to other are significantly higher that prescribed values.

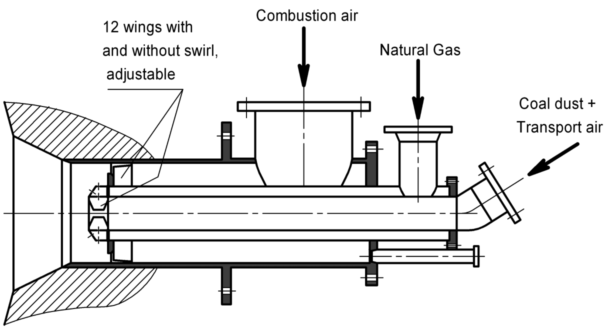

Figure 1. Schematic design of BIFS coal dust-natural gas multi-fuel firing system.

In a recently published papers [8, 9] authors illustrated the development, manufacturing, testing and operation experiences of the BIFS combustion systems for heating-up of coal gasification reactor, where specific conditions are prevailing (high pressures, high temperatures, inert atmosphere, etc.). In this contribution the following two multi-fuel burner systems will be presented in details: a) Pulverized coal-gas; b) Pulverized coal-oil.

BIFS manufactured both burner systems for thermal power from few kW to several MW. The pressures for gas, coal dust, oil and combustion air ahead of the burner is adjusted according to the requirement of the combustion process. The control range is about 1:5 by thermal output. The excess air factor can varies up to 2.

At this point it should be noted that the BIFS firing systems are not mass-products (repetition parts), not being in series (not lot production), but manufactured according to the specific process requirements and customer requests. These systems have demonstrated already their energetic-economic as well as environmental benefits through many years of practical operation in various industrial facilities and under specific opration conditions.

Multi-fuel burner systems

a) Pulverized Coal-Gas Firing System

The construction of BIFS multi-fuel firing system for pulverized coal-natural gas operation is illustrated in Figure 1 schematically. While the coal dust is transported into the burner by the conveying air (transport air), the natural gas is led separately in the cylinder ring and from there into the combustion chamber. Both the coal dust and the natural gas admix at the burner outlet with the main combustion air. Through the variable swirl wings placed in both air flows it is possible to ensure left swirl, right swirl or counter-rotating swirl, thus the flame shape and length can be adjusted to the required operation demands. This combined burner system is working since many years successfully in coal drying and lime treatment plants without any troubles.

b) Pulverized Coal-Oil Firing System

Figure 2 shows the design of BIFS multi-fuel firing system for pulverized coal-oil operation schematically. The fuel oil is led through a central lance up to the burner tip and then it is injected as spray into the combustion chamber through the burner nozzle. The coal dust is transported in a cylindrical ring around the oil lance by means of conveying air until the burner mouth and admixed there with the oil by adjustable swirl wings. Through the secondary air, which is led swirled or un-swirled, the mixing process can be influenced so that the desired flame geometry is set. BIFS produces this multi-fuel firing system for different thermal powers. It is used in steel mills, rotary kilns or as a charcoal burner.

BIFS equips the burner system with the pulverized coal dispenser and belonging metering

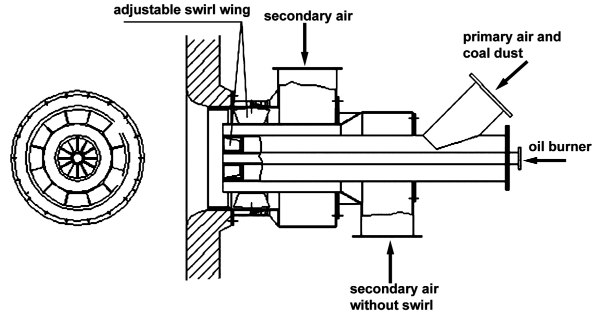

Figure 2. Schematic design of BIFS coal dust-oil multi-fuel firing system.

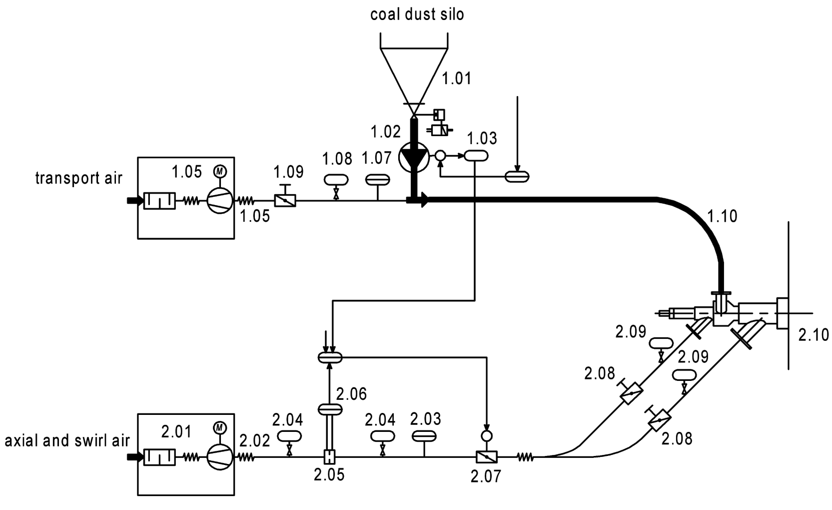

Figure 3. Flow chart for the combined coal dust-oil burner system: 1.01 — silo valve; 1.02 — control equipment; 1.03 — speed transmitter; 1.04 — dust nozzle; 1.05 — fan; 1.06 — compensator; 1.07 — pressure switch; 1.08 — manometer; 1.09 —adjusting flap; 1.10 — dust pipe; 2.01 — fan; 2.02 — compensator; 2.03 — pressure switch; 2.04 — manometer; 2.05 — measuring orifice; 2.06 — transmitter; 2.07 — control flap; 2.08 — adjusting flap; 2.09 — manometer; 2.10 — burner.

unit. The dispatcher, whose main element is a high-speed auger, guarantees for the transport of the coal dust needed for the combustion process. The coal dust passes into the primary air line through the continuously adjustable injecting screw. From there it is captured by the conveying air and fed directly through the blast duct into the coal burner. The required air amount for the combustion process is the sum of the conveying air of coal dust (transport air) and the secondary air supplied separately to the burner.

The flow charts for the pulverized coal/transport air and secondary air/swirl air to the burner are presented in figure 3 illustrating the functionality of the pulverized coal charge dispatcher. The positioning of the coal charge dispatcher and dosing unit is shown and their function is indicated. In addition, the flow diagram contains of all associated fittings for measuring, control and safety devices. It illustrates their sequence for the safe and reliable operation of the burner.

Burner operation and optimization

As an example of BIFS activities in optimization of burner performance, the multi-fuel firing system «pulverized coal — gas burner» presented in figure 1 is explained more in details when adapted to an oven of a calcination plant. The gained operational experiences are also described.

Two burners of this multi-fuel firing system are working since several years on hot gas generators of a calciner. The burner capacities are 5 and 12 MW_{th}, respectively. BIFS also constructed, built and installed the natural gas and coal dust trails and equipped them with associated safety and control devices. Furthermore, the dust trails were fitted with the complete accessories for the dust storage (silos), the dust transport (weighting and dosing, feeding), the dust conveying (air blowers) and so on. BIFS undertook also the commissioning process.

Figure 4 illustrates the installation position of the burners on the oven. As seen they are built into the cover of combustion chamber as «ceiling burners». Thus, the burn-out direction is implemented from top to bottom. In this way it is ensured that each carbon dust grain goes through the entire reaction area so that an optimal combustion takes place und burn-out occurs.

The operation of the gas burner is initially required for the drying of the refractory material of the combustion chamber, after that it is used for the start-up of the process and for conditionally operation situations. The ignition of natural gas is made electrically, the pilot flame is controlled through an ionization detector and the flame of main burner is controlled by a combined UV/IR flame detector. In case of any unsuccessful ignition the flow of natural gas is automatically prevented by closing of the solenoid valve. After reaching the required ignition temperature for pulverized coal, the control sys-

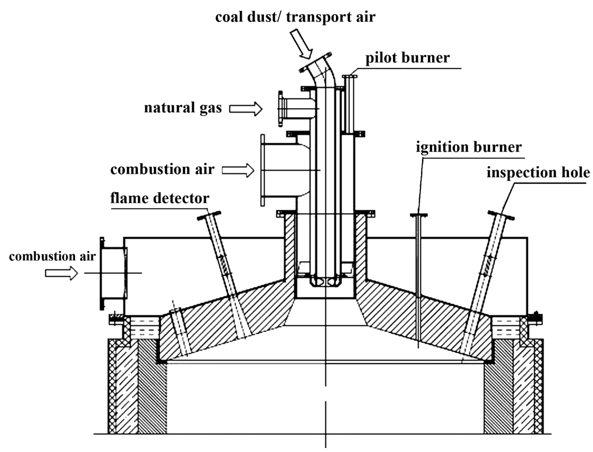

Figure 4. Coal dust-natural gas burner built-in at the roof of the furnace for a calciner.

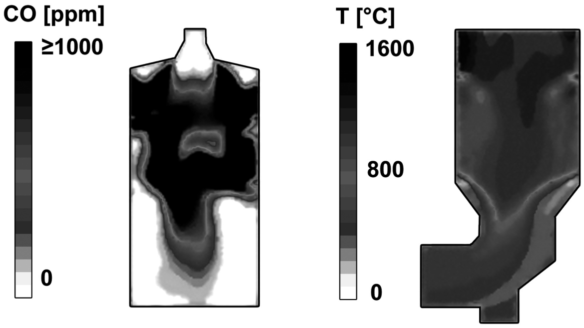

Figure 5. Simulation results for the distribution of CO in the upper furnace part, temperature in the lower furnace part.

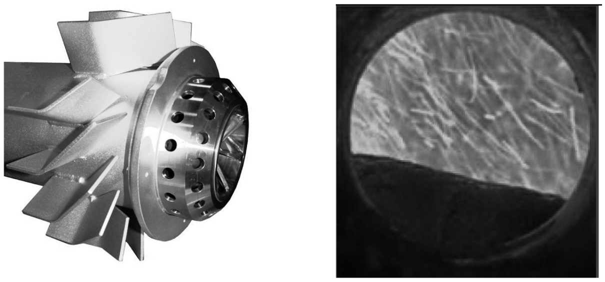

Figure 6. Photographs of the coal dust-gas burner head and its combustion behavior.

tem permits the addition of the coal dust. The combustion temperature is kept below the ash melting point, so that the undesired slag formation is avoided. This is achieved by the admixing of cooling air.

To optimize the combustion and improve the burn-out a part of the secondary air is blown later tangentially into the combustion chamber. In addition, fresh air is introduced at a further downstream position tangentially. Thus the coal dust, which is swirled and led into the cylindrical combustion chamber by the conveying and secondary air, is brought on a rotating circle-like path. This increases and prolongs the burn-out and retention. As a result a complete burn-out and a homogenous distribution of hot gas can be achieved. Thus the flue gas temperature at the furnace exit matches well with the required process temperature.

The hot gas generated by the burners is directed to the output of combustion chamber. Shortly before discharging it is mixed with additional return gases, so the required quantity and temperature for the process are assured. Then it is used for drying the product.

To predict the combustion behavior mentioned above, CFD simulations were performed by order of BIFS for a reference case. An extract of the results is presented in figure 5. The following performance can be confirmed: while the CO concentration shown on the left-hand part of the figure is hardly detectable up the middle of the oven, a uniform temperature and velocity profiles are calculated at the oven outlet (see middle and right parts of the figure). The best burner variant with optimal results was built in the BIFS workshop and used at the calcination plant. Figure 6 shows on left-hand part a photograph of the burner head, where the following components can be seen: the swirl blades in the inner tube for the transport air and coal dust, the natural gas nozzles on the cylinder ring and the swirl blades for the secondary air at the outer tube.

Up to date the burner is working trouble-free. It provides a stable combustion and meets the required exhaust gas properties for the product. The combustion photo on the right-hand part of figure 6, taken through an observation window at the top of the combustion chamber, gives a good uniform and stable combustion of the coal dust.

Conclusions

Based on the operational experiences gained up to now with the multi fuel burners (coal dust-natural gas) it can be stated that:

— Burners work stable and reliable with both types of fuel (natural gas and coal dust) in a near-stoichiometric conditions (λ = 1,05 to 1,1);

— A wide control range is possible;

— Burner operation is user-friendly and needs low maintenance;

— A complete burn-out is achievable;

— Generated hot gas meets the required drying temperature.

Adaptable fuel mixture allows cost-optimized operations.

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Многотопливные горелочные устройства для промышленного применения

Многотопливные горелочные системы используются в различных промышленных процессах, на ТЭС и в металлургии, включая сухое измельчение сырых материалов, во вращающихся печах, промышленных котлах, установках когенерации и специальных термических технологиях. Соответствующие системы должны быть пригодны для использования различных видов топлива и гибко реагировать на изменения его состава и качества, в частности, необходимо учитывать устойчивость воспламенения топливной смеси и сопутствующее загрязнение окружающей среды. Такие системы должны обеспечивать эксплуатационные параметры и экологические нормативы в соответствии с германскими техническими стандартами качества воздуха (TA Luft 2002 г.). Качество работы этих многотопливных систем определяется, с одной стороны, пусковыми условиями (например, сушка огнеупоров, создание требуемой рабочей среды), с другой стороны, эксплуатационными требованиями, колебаниями цен на сырьевые продукты и готовые товары, а также условиями, учитывающими специфику технологии, нестабильное снабжение топливом. Принимается во внимание также внутренняя утилизация отходов в пределах производства. В статье рассмотрены две многотопливные горелочные системы, выбранные из обширной производственной номенклатуры ООО «Бринкман». Соответственно представлены системы комбинированного сжигания пылеугольного и газового топлива, а также пылеугольного топлива с жидким топливом. *Библ. 9, рис. 6., табл. 1.*

Ключевые слова: газо-угольная горелка, комбинированная жидкотопливно-угольная горелка, загрязнение атмосферы, распыленное топливо, TA Luft, мощность горелки, режим эксплуатации.

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Багатопаливні пальникові пристрої для промислового застосування

Багатопаливні пальникові системи використовуються у різних промислових процесах, на ТЕС та у металургії включно з сухим подрібненням вологих матеріалів у обертових пічах, промислових котлах, установках когенерації та спеціальних термичних технологіях. Відповідні системи мають бути придатними для використання разних видів палива та гнучко реагувати на зміни його складу та якості, зокрема необхідно враховувати стійкість займання паливної суміші та супутне забруднення довкілля. Такі системи мають забезпечувати експлуатаційні параметри та екологічні нормативи у відповідності до германських технічних стандартів щодо якості повітря (TA Luft 2002 р.). Якість роботи цих багатопаливних систем визначається пусковими умовами (наприклад, сушіння вогнетривів, створення потрібного робочого середовища) та, експлуатаційними вимогами, коливаннями цін на сировинні продукти та готові товари, а також умовами, що враховують специфіку технології, нестабільне постачання палива. Приймається до уваги також внутрішня утилізація відходів у межах виробництва. Розглянуто дві багатопаливні пальникові системи, вибрані з великої виробничої номенклатури ТОВ «Брінкман». Представлено системи комбінованого спалювання пиловугільного та газового палива, а також пиловугільного палива з рідким паливом. *Бібл. 9, рис. 6, табл. 1.*

Ключові слова: газо-вугільний пальник, комбінований рідкопаливно-вугільний пальник, забруднення атмосфери, розпилене паливо, TA Luft, потужність пальника, режим експлуатації.

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Основные положения технологии точного нагрева в пламенных печах садочного типа

Предложена технология точного нагрева крупногабаритных изделий и садок в пламенных печах, в частности, камерных термических и туннельных. Технология базируется на организации интенсивной внутренней рециркуляции греющих газов вокруг нагреваемых тел. Движение газов осуществляется по специальным рециркуляционным контурам. Геометрические и режимные параметры контура рециркуляции рассчитываются по предлагаемой методике. Основой этих контуров являются скоростные газовые горелки с предварительной подготовкой смеси газа и воздуха. Разработаны и аттестованы к применению на промышленных печах три типа скоростных горелок: ГН и ГН(Н) со специальным огнеупорным туннелем, в котором происходит полное или частичное сгорание смеси; ГНБ, обеспечивающие полное сгорание смеси в малогабаритном факеле в свободном рабочем пространстве; ГНБ-ТГ, обеспечивающие низкотемпературный скоростной поток продуктов сгорания. Технология точного нагрева успешно используется при термической обработке металла и обжиге керамических и огнеупорных изделий. *Библ. 9, рис. 5, табл. 1.*

Ключевые слова: технология нагрева, рециркуляция газов, равномерность нагрева, скоростная горелка, печь садочного типа.