Role of ignifluid steam generators in the performance upgradation of paper plants

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SUMMARY

The matter of burning alternative low grade fuels, has long left the wings, to occupy the centre stage, stirring concern and action across the industries of the world.

Today, there is an urgent need for boilers designed to abate pollution, utilise waste fuels, thereby conserving our natural resources, and produce energy.

IGNIFLUID—the only commercially proven high-temperature technology to feature all the above points has received critical acclaim around the world from designers and users alike.

The paper gives an insight into this revelutionary boiler design. Performance of two installations in India has also been discussed.

As we get together to dwell upon the energy problems of the paper industry we call upon that unbeatable ingenuity of man, that took the world from the flintstone spark, to the modern industrial furnace.

Since the energy crisis, fludized bed combustion has been the subject of considerable research and development work.

LIPI BOILERS PVT. LTD., a Poona based company dedicated to the reliable generation of steam, now presents in colloboration with the renowned FIVES CAIL BABCOCK of France, IGNIFLUID—a high temperature Fluidised Bed Technology; is commercially developed since 1955, over 5,000,000 operating hours on more than 30 installations world wide, stand in mute testimony to its flawless superiority.

PRINCIPLE OF IGNIFLUID :

Coal combustion in an Ignifuid furnace makes use of the formation, in a fluidised bed, of a relatively dense layer of particles held in suspension, using a high gas superficial velocity in the same range as in a "Fast bed" or "Circulating bed". This velocity region ensures a high mean relative velocity between gas and solids, well above the terminal velocity of the particles. Moreover the trapezoidal shape of the vertical section of the bed induces a high rate of in-bed solid recirculation and allows high velocities at the bottom, without excessive carry-over at the top. The specific heat release rate of Ignifluid, as a consequence, is more than 10 times the corresponding rate of the bubbling bed.

The bed itself contains solely incandescent coke, which burns when in contact with the fluidizing air. The thermo-chemical phenomena which occur inside the bed, apart from Carbon oxidation, are controlled by 3 main balancing reactions :

$$CO_2 + C \rightarrow 2\,CO = -41.2 \text{ Kcal/Mol.}$$

$$CO + H_2O \rightarrow CO_2 + H_2 = -10.0 \text{ Kcal/Mol.}$$

$$C + 2\,H_2 \rightarrow CH_4 = +17.9 \text{ Kcal/Mol.}$$

It is these reactions which, maintain the equilibrium of temperature in an Ignifluid furnace.

The combustible gases which leave the bed are burnt in a heavy imbalance zone situated above it, with addition of secondary air.

Combustion takes place in two stages—

One, inside the bed, where there is a large reserve of incandescent fuel, due to the fluidizing air which acts as primary air; the other, above the bed by the

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monitored addition of secondary air.

THE IGNIFLUID COMBUSTOR :

The design of the Ignifluid combustor is characterised by two main features :

(1) The use of an inclined chain grate for 2 purposes—

(a) To blow the primary air into the bed, through narrow slots, at a short pitch, giving an excellent air distribution.

(b) To selectively extract the ash from the bed.

(2) The provision made for natural fuel banks on both sides and at the front end of the bed, with 2 purposes :

(a) These banks protect the walls of the combustor from fouling, erosion and corrosion.

(b) They naturally form the favourable trapezoidal shape mentioned above.

INSTALLATIONS IN INDIA :

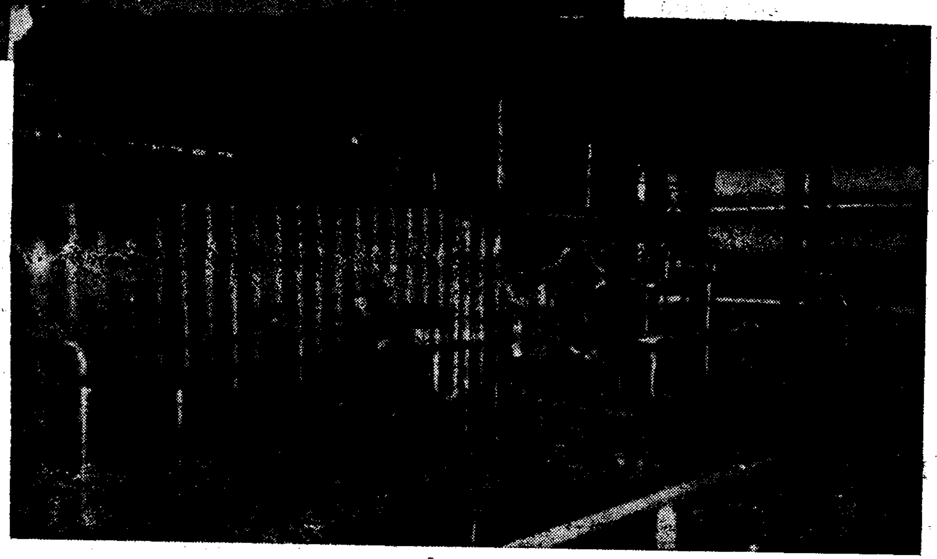
Keeping in view the redundance of the old steam generators designed to handle high grade fossil fuels and furnace oil, coupled with the need for efficient, multifuel fired boilers, Tamil Nadu Newsprint & Papers Ltd. (referred to as TNPL) opted for Ignifluid.

The country's first bagasse based newsprint plant, TNPL has an annual capacity of 50,000 Te for newsprint, and 40,000 Te for paper (see fig. 1–A).

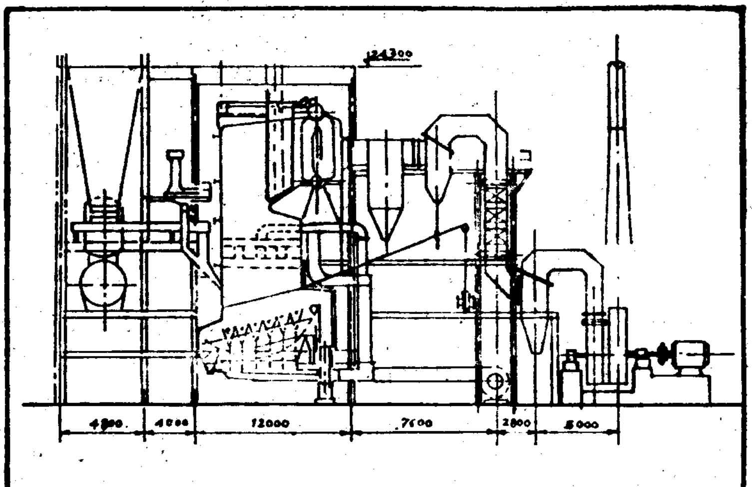
Closely on the heels of TNPL, is Seshasayee Paper & Boards, Erode (refereed to as SPB), a premier paper plant of South India, who also opted for Ignifluid (see fig. 2–B).

The primary objective of selecting this high temperature fluidized bed technology, is its efficiency in burning a wide range of fuels. Steaming details of the battery of Ignifluid steam

1A—Overall Plant View of TNPL



1B—View of Steam Drum in Erected Condition



LIPI BOILERS P. LTD. PUNE MARCH-1985 | SESHASAYEE PAPER AND BOARD INDIA 40T/Hr IGNIFLUID STEAM GENERATOR | FIG. 2

generators employed in both the plants are appended in Table 1 A.

The total energy concept has picked up in the paper industry, along the lines of cogeneration. Substantial saving in steam consumption per KWH of power generation can be envisaged by going in for highest practical pressure expanded to the lowest possible pressure, in confirmity to the typical constraints faced by industrial mills for power generation. Both TNPL and SPB have gone in for simultaneous generation with the steaming conditions fixed accordingly. Refer Table 1 B.

Steam generator No.	Make	Fuel	Steam evap. TPH	Steam outlet Pr (Psig)	Steam outlet temp.
SESHASAYEE PAPER & BOARDS LTD.					
1.	Babcock & Wilcox	Coal/Oil	15.9	400	700°F
2.	Babcock & Wilcox	Coal/Oil	15.9	400	700°F
3.	Babcock & Wilcox	Oil	18.2	400	700°F
4.	Babcock & Wilcox	Oil	17.0	250	500°F
5.	Thompson	Coal/Oil	25.0	400	700°F
6.	Babcock & Wilcox	Recovery liquor/Oil	14.6	—	—
7.	Babcock & Wilcox	,,	17.0	—	—
8.	FCB/LIPI	Coal/Lignite	40.0	425	716°F
TAMIL NADU NEWSPRINT & PAPER CO.					
				Kg/cm²g	
1.	FCB	Coal/ Leco	60.0	44	440°C
2.	FCB	Bagasse pith/ Furnace oil	60.0	44	44°C
3.	FCB	,,	60.0	44	440°C
4.	Mitsubishi (recovery)	Black Liquor	30.0	44	440°C

LIPI BOILERS PVT. LIMITED March, 1985. — The Steam Generators — Table 1 A

	CLIENT	
	Seshasayee Paper & Boards	Tamil Nadu Newsprint
Location	Erode, Tamil Nadu	Pugalur, Tamil Nad
No. of units	1	3
Steaming Conditions		
Capacity, TPH	40	60
Peak, TPH	44	66
Operating Pressure, Kg/cm^{2}g	30	44
Steam Temperature, °C	380	440
Feed Water Teamp., °C	104	105
Efficieney on CCV at 100% MCR	Coal (50% ash) =77% Lignite (53% moisture) =65.4% Lignite (40% Moisture) =72%	Coal (47% ash) =77.7% Leco=89.4%
Special Features		Bagasse pith containing max. 70% moisture can be burnt with coal or leco.

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Characteristics of Ignifluid Boilers in India.

Table 1 B

A wide spectrum of fuels, covering low grade coals (50% ash) to high moisture fuel (Lignite of 53% moisture) are proposed to be burnt in these steam generators. Even bagasse pith, a waste product of the paper mills (with a moisture content of max. 70%) is envisaged to be burnt alongwith raw lignite, carburized lignite or coal. The characteristics of fuel to be handled are detailed in Table 2.

UNIQUE TECHNICAL FEATURES OF IGNIFLUID COMBUSTORS :

Wide Fuel Versrtility :

The Ignifluid furnace can efficiently burn bitumunious coal or anthracites with 6% volatile matter and meta anthracite with 2% volatile matter, to lignite; from non-caking to high caking coals even with a considerable amount of fines (1 mm). Fuels with 55% ash have been burnt in an industrial plant and up to 70% ash in the pilot plant at La Courneuve, near Paris. Poor oil shales have also been successfully fired in this pilot plant. Waste fuels such as coffee grounds, used lubricating oils, coal washery rejects, coke breeze etc. have been burnt efficiently in Ignifluid plants.

Fuel Sizing :

The design is not very demanding as regards the granulator spectrum of the fuel. A 0%10 mm size that is required is achieved by normal crushing. The boiler is fed directly with raw coal supply falling by gravity into the furnace.

As the grinding equipment constitutes a high capital expenditure, and uses a great amount of energy and spare parts, an Ignifluid boiler turns out to be much more economical to buy and operate than a pulverized coal fired boiler; or even the conventional fludized bed boiler that requires a —6 mm grain size.

Greater Operation Flexibility :

An Ignifluid boiler offers excellent flexibility during quick and substantial load variations, comparable to oil firing. The technical minimum under automatic regulation is in the region of a quarter of a load whereas the load fluctuation is only from 1—2 for a pulverized coal fired boiler, with a given number of mills on operation. An Ignifluid boiler therefore is better suited than a pulverized coal fired boiler to the operating conditions of plants where it is often necessary to deal with greater load fluctuations and frequent stops.

Furthermore, re-startup is carried out in a very short period by re-fluidizing the coal and embers and does not require any auxiliary fuel.

The conventional fluidized bed furnaces too, are not very flexible and require several beds, successively lit up and put out, to obtain substantial ranges.

The Ignifluid furnace, by virtue of its self stabilizing combustion and its large reserve of ignited carbon, allows a wide

	SPB			TNPL		
	Coal	Lignite	Coal	Lego	Bagasse pith	Furnace oil
PROXIMATE						
Ash	50	3	47.05	13.30	6.19	**Spec. gravity** —0.94 to 0.95@ 32—35°C. **Viscosity** 1700 RW, NS @27°C, 410@ 50°.
Moisture	8	53	7.22	7.65	10.19	
Vol. Matter	22	24	21.95	9.94	67.65	
Fixed Carbon	20	20	23.78	69.11	15.97	
ULTIMATE						
Ash	50	3.05	47.05	13.30	6.81	
Moisture	8	53.00	07.22	7.65	10.19	
Carbon	34.86	30.03	37.62	70.86	41.08	
Hydrogen	2.77	01.43	02.46	1.46	05.21	
Oxygen	3.30	11.61	04.58	5.06	30.28	
Sulphur	0.42	0.62	0.37	1.05	0.09	
Nitrogen	0.63	0.26	0.70	0.61	0.34	
HEATING VALUE						
Gross Cal. Value, Kcal/kg	3600	2450	3783	6875	3984	10,120

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Characteristics of Fuels to be burnt in Ignifluid Steam Generators.

Table—2

variation of load under automatic regulation, without any risk of disturbing the grate.

No In-bed Heating Surface :

Unlike Ignifluid, cooled bed furnances have tubes in their beds which are subjected to corrosion and erosion. Superheater coils are unavoidable in the case of conventional fluidized bed combustors, especially with very high steam exit temperature requirement. In Ignifluid design, superheater is located at the furnace exit, as envisaged in a conventional boiler.

Lower Electric Power Consumption :

The auxiliary equipment of an Ignifluid boiler consumes much less energy than that of a pulverized coal fired boiler. If the power rating of the F.D. Fan is higher, the difference is far from reaching the power consumed by the grinding equipment. On an average a pulverized coal fired boiler consumes about 150 KW more than an Ignifluid boiler per 100 TPH of steam produced. The electricity consumption as compared to the bubbling bed too, is less, which requires a higher air pressure.

All Ash Discharged as Clinker :

Another typical feature of the Ignifluid lies in the fact that agglomeration of ash as clinker is allowed to occur in the bed, so as to ensure a selective extraction of the mineral matter. As a result, the bed material has a high percentage of carbon in contrast to the situation of the bubbling bed, which usually consists of approximately 99% ash.

The ash aglomeration phenomenon inside the fluidized bed makes it possible to reinject into the furnace, the ashes collected at various collection points and below the electrostatic precipitator, without the risk of abnormally increasing the fly ash rate in the flue gases. A single point ash discharge restricts pollution to the bare minimum.

No Auxiliary Fuel Required :

As opposed to pulverized coal boilers, Ignifluid does not need any auxiliary fuel—either to burn anthracituous type of coal, even with a low content in volatile matter, or to operate low loads.

Feed Water Quality :

The quality of feed water, unlike that for conventional fluidized bed combustor, needs no more than that required for conventional units.

Dust Collection :

Carry-over, collected in 2 stages of grit collectors, the first being mechanical and the second usually electrostatic is entirely refired in the furnace. All the ash is finally extracted from the boiler by the grate in an agglomerated form at one single point. The location of these grit collectors also ensures that the erosion of the economiser coil is minimal.

This also dictates the need to install soot cleaners.

Higher Thermal Efficiency :

Because of its higher operating temperature–1050°C 1200°C, the selective sintering of ashes, and the effectiveness of its soot reinjection systems, the Ignifluid furnace achieves a higher efficiency. It ensures a better combustion of low grade fuels, by virtue of its high temperature. Its elongated horizontal section, limits back-mixing of solids to a minimum, thereby enabling a good carbon burn-up efficiency especially in non-agglomerating conditions. The absence of 'bubbles' which partly act as an air by-pass in the bubbling bed, also assists the high contact efficiency of carbon with oxygen or carbon dioxide in the Ignifluid furnace.

Less Space Requirement :

Ignifluid combustors have a low grate area requirement and therefore easy fuel feeding and easy scale up. This area requirement is 10 times less than for the bubbling bed and is the consequence of 2 facts—

(a) The superficial gas velocity is high.

(b) Roughly, only half the combustion air is introduced through the grate.

Large Turn-down Ratio :

Wide turn-down ratio in a single bed, as a consequence of a roughly constant bed temperature and of the special geometry of the bed with a self-varying effective grate area.

NOX Content Lower By Half :

Combustion in 2 stages is one of the ways to reduce the NOX content in the flue gases. The formation of these oxides is indeed all the more intense as the maximum combustion temperatures are high. By its very design, the Ingnifluid furnace carries a 2 stage combustion.

Experience :

Ignifluid, has the highest unit capacity yet reached among fluidized bed boilers; steam generation capacity—190 TPH; a 380 TPH boiler is under execution while a 700 TPH boiler is available in the design stage.

The Cost Factor :

The capital cost of Ignifluid boilers above 100 TPH is not much higher than the one of Spreader Stoker boilers; it is much lower than the one of pulverized coal boilers which cost approximately 15 to 30% more due to their directly related equipment and their necessity to have a taller furnace.

INSTRUMENTATION & CONTROL :

Instrumentation and control incorporates all appliances for monitoring, actuation, control and automation of the process. Warn up systems in the form of annunciation and alarms are connected with important measurement deviation from set point. Extensive automation of start up and load changes and normal operation, along with automatic tripping a faulty conditions are incorporated.

Being highly critical the instrumentation and control systems in Ignifluid are so designed, as to be easily hooked to microprocessor based systems. SPB, an Ignifluid installation in India has gone in for such a system for their steam generator.

CONCLUSION :

Ignifluid, is the only AFBC process which has stood the proof of more than 500,000 operating hours in a normal industrial environment.

Due to its versatile fuel flexibility and ability to handle low volatile and high ash content fuels, the pay back period is very short.

With the average calorific value of coal supplied to the paper industry being 3500 Kcal/kg, and ash content of 40—45%, it is impossible to achieve an efficiency of more than 60% in conventional boiler.

Paper mills, with integrated pulp plant, use approximately 10 Te of steam per tonne of paper produced, therefore requiring 2.93 Te of above grate of coal, using a Spreader Stoker. This requirement goes down to 2.42 Te with the same variety of coal, using an Ignifluid boiler—Effectively, a saving of 0.51 Te of coal for every tonne of paper produced. The saving may be only 60% of this figure for mills without an integrated paper plant. Thus we take an average of roughly 0.4 Te of coal saving per tonne of paper produced. The total possible saving of coal in our country for producing paper, if all paper mills had Ignifluid boiler is computed in Table 3.

The late rediscovery of the merits of fast beds, in many countries is a confirmation of the soundness of the principles

Parameters	Spreader Stoker	Ignifluid	
Steaming Conditions			
60 TPH steam generation at 44 Kgf/cm²g & 400°C.			
Fuel	Coal	Coal	Coal and Pith
Coal consumption/unit, TPH (47% ash and GCV of 3783 Kcal/kg)	14.9	13.9	12.3
Basis : 1 tonne of steam			
Coal cost, Rs. (Coal rate : Rs. 600/Te)	149	193	123
Power cost, Rs.	2	3	3
Labour cost, Rs.	0.6	0.6	0.6
Maintenance cost, Rs.	1.9	1.0	1.0
Water cost, Rs.	1.0	1.0	1.0
Investment cost, Rs.	4	6	6
Total steam cost, Rs.	158.5	150.6	134.6
Cost saving with Ingnifluid, Rs.	—	7.9	23.9
Annual saving with Ignifluid, Rs. Lakhs	—	38	115
Total annual saving with Ignifluid for 2 boilers, Rs. Lakhs	—	76	230

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Table—3

Comparison of savings accuring by switching over from Spreader to Ignifluid System.

upon which the Ignifluid is based.

References :

1. A. Godel—'ANew Combustion Technique" Engineering and Boiler Houss Review, Vol. 71, May 1956.
2. A. Godel—"The Ignifluid Bed Combustion Process and its Precast Stage of Industrial Development." First International Conference on Fluidised Bed Combustion, Houseton Woods State Park, Chic, November 18-22, 1968.
3. P. Coser—"Latest Operating Experiences with the Fludised Bed Combustion in Ignifluid Boilers."
4. P. Coser—"Operating Experiences with the New Fluid Bed Boiler of the Paris district Heating System.