OPTIONS FOR SAVINGS IN BOILERS IN MODERN RICE MILLS

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1.0. INTRODUCTION

Rice is the key food item, which has seen many technological changes right the way it is produced, processed and distributed. There was a time in my childhood, my mother used to boil the paddy at home, then dry up in the sun. I used to carry the boiled paddy to a local rice mill, where rice hull is removed and polished. Times have changed a lot. There is dramatic change in mass production of rice using modern technology of parboiling, steam – hot air drying and then milling. Today machinery is available for separating the colored rice from the bright white rice. I have been watching the trend in the operation of boiler, which is an important and costly input to rice industry. I would like to consolidate here critical energy saving aspects of boiler operation.

2.0 COMBUSTION TECHNOLOGY OPTIONS

The choice of combustion technology was always dependent on fuel used. Rice husk is a popular fuel for many rice mills. Yet it is seen that in some parts of India alternate fuels are available at low prices. For example in Kerala, plywood waste is available in plenty. Rice millers prefer to sell off the rice husk to other industries where high capacity boilers are designed for rice husk. This improves overall economy of the rice mill.

2.1 STEP GRATE COMBUSTOR

When rice husk is the fuel, step grate was the primitive technology used. As shown in *Figure* 1, the combustor is made of a refractory furnace with an inclined grate. The grate consists of number of horizontal cast iron plates mounted on cast iron support frame. The thickness of the CI plates would be 10mm. Approximately 3 m^2 burning area is required for one ton per hour of boiler capacity. In this case, the air is drawn through the burning bed of husk by natural draft created by the chimney. Alternately an ID fan may be used to draw the flue gas. The burning rice husk should be uniform over the bed. The fuel feeding should be regulated through a feeder having a discharge width, over the width of the furnace. The ash removal should be continuous to the extent possible.

The combustion never used to be any better than the other available technologies. The ash had to be manually removed. The boiler needs to be constructed in a pit. Or else, the boiler shell should be elevated and be provided with operating platform. The boiler may be single pass or two pass boiler.

2.2 FIXED GRATE REFRACTORY FURNACE.

Fixed grate furnaces are available in many parts of the country. The husk stored in the bunker is fed to the furnace through a regulating device usually a vibratory or a screw feeder. The husk is spread over the grate by an air spreading arrangement. The husk is burnt statically over the bed. The FD fan supplies air to the bottom of the grate. An ID fan draws the flue gas from the furnace. The ash needs to be removed manually. The firing is done in external furnace or in an internal furnace of the boiler. *Figure 2* shows the view of external furnace. *Figure* 3 shows the view of Waterwall furnace.

2.3.POF FURNACE.

This is basically a fixed grate furnace inside the boiler. The grate area is so less, the rice husk when fed into the furnace, it burns in suspension, travels through the flue tubes and finally reaches ash room. Thus the handling of the ash inside the furnace is avoided. This is a favorite among mills of 20 Tons per day capacity. The husk is pneumatically transported from the storage room to the furnace. Alternately the husk may be fed into the furnace by means of screw feeder and assisted by the additional air. The requirement of ash removal from the furnace does not arise in this case. Of late, the ID fan is not provided. A variation of grate furnace is now a refractory lined distributor plate which has overcome the shortcomings of the grate bar design. *Figure* 4 shows the distributor plate furnace.

2.4.FLUIDISED BED FURNACE

Fluidized bed combustion employs a distributor plate, a bed of sand. The bed of sand is kept fluidized state by the FD fan. A PA fan is used to transport and inject the rice husk into the bed. The bed of sand is initially heated by charcoal / or rice husk. Once the sand is heated and maintained in fluidized condition, the rice husk is continuously injected to maintain the combustion and to give the heat required for generating the steam in the boiler. The ash after complete combustion leaves the bed and gets collected in ash hoppers of the boiler & in the dust collector. An ID fan is used to maintain the negative draft in the furnace. Pollution is the big issue here. One should have properly designed & installed MDC cones. *Figure* 5 shows the sectional view of a fluidized bed combustion boiler. This technology is widely accepted in industry for its fast load response and high combustion efficiency. Unfortunately, the power consumption is high and hence it is viable for 6 TPH and above.

3.0 BOILER OPTIONS

3.1. LANCASHIRE BOILER

Oldest boiler and has already walked out to scrap yard. Yet It is found at some places. This boiler needs an external step grate or fixed grate furnace as shown in *Figure* 1. The flue gas passes through the flue / flues of the boiler. The boiler has multiple flues arranged around the furnace to exchange the heat. The ash settles through the entire flue path, which is removed manually at regular intervals. A slow performer. But holds lot of water. So when the steam is drawn the steam may be more produced by the flashing of steam which will be due to reduction of pressure. It is time to erase this boiler out of industry. The reason is the high fuel consumption as the flue gas leaving the boiler is of high temperature.

3.2 LOCOMOTIVE BOILER.

Locomotive boilers were once favorite for many for its sturdiness. With the use of feed water heater one could achieve low exhaust temperature as in any modern boiler. Locomotive boilers are provided with 3 / 3.5 / 4 inch tubes. The tubes are longer. There is a water-cooled chamber in the furnace. The refractory furnace with step grate or flat grate as required for husk firing is provided. It is this that makes it lower efficient. Then one may say “I have FBC in my boiler “. An FBC combustor without bed coils runs on excess air, which also lowers the combustion was not developed at that time. In the riveted boilers any flame cutting would lead to loosening of rivets. For this reason no repairer or boiler vendor would venture to modify this boiler.

3.3 SINGLE PASS MULTI TUBULAR SHELL BOILER.

A single pass shell tube boiler is an economic boiler. The boiler tube length is of 4 to 4.5 meters. The flue tubes are provided with gas spirals to improve the heat transfer in the tubes. Often It is observed that operators remove these spirals since it chokes up the tubes. The choice of combustor is fixed grate or FBC. In this range the FBC is uneconomical due to its high power consumption. The external furnace is the only choice. The ash has to be removed manually from the ash settling chambers provided after the furnace. Some boilers are provided with bed coils so that the efficiency improves due to reduction in excess air. In the case of FBC over bed feeding is opted as it is simpler. Some customers have taken a stationary grate combustor with large furnace area when the option of firing wood or plywood waste was required.

A long flue path ensures good carbon burn up. A feedwater heater is a must to recover the heat from the flue gas before it leaves chimney. See *Figure* 9, showing the boiler with feedwater heater. In rice mills the batch operation permits the operator to remove the ash manually from the ash settling chambers.

3.4 MULTI PASS MULTI TUBULAR SHELL

A multi pass tubular shell eliminates the need for gas spirals. The flue gas velocities are optimum and the gas is cooled very well. The feedwater heater is a must to recover the heat. The boiler can be designed for an exhaust temperature of 170^{o} C.

The choice of furnace can be FBC or fixed grate. Fixed grate option is selected for firing multi fuels such as wood or rice husk or plywood. If the choice is FBC, then the bed coils are necessary to have low excess air. Response is good. Over bed feeding is OK provided sufficient refractory lined flue path is available to ensure good carbon burn up. Airheater is the right option if FBC technology is opted for.

3.5 WATERWALL CUM MULTI TUBULAR SHELL BOILER

As the capacity goes up one has to come here. The water-cooled furnace is a must to ensure the boiler runs without much trouble from refractory. These boilers are with fixed grate or a fluidized bed combustor.

In case you want to fire coal also in fixed grate furnace, the same would be possible manually. The water-cooled chamber is placed directly above the furnace. *Figure* 14 shows the view of a waterwall cum shell type boiler with fixed grate furnace for coal / husk / wood / plywood / bagasse / GN shell.

In case of FBC, the underbed offers flexibility in turndown and maintains good efficiency over the overbed. The overbed firing allows escape of rice husk to ash settling chamber. The underbed ensures the husk is better burnt before the husk escape the fluidized bed. The overbed feeding has been found to cause bunker fires as the flue gas can easily enter the bunker during a furnace puffs. The excess air required for overbed combustion is of the order of 60 to 70% whereas the underbed can easily make it at 25%. Since the excess air fired is more in Overbed FBC, The boiler has to have more convection heat transfer surface. The spirals are used here again to recover the heat. Operators find that the flue tubes are choked up due to spirals and hence these are removed later. The exhaust gas temperature will be more, once the spirals are removed. Underbed feeding allows one to have a good turndown due to the number of compartments.

4.0 SCOPE FOR IMPROVEMENT IN BOILERS.

4.1. The insulation of the boiler is intact in almost all the mills where I had visited. However the steam piping is either not insulated or spoilt over a period. The uninsulated pipes lead to additional fuel consumption.

4.2. Some clients desire that the boiler operates on pressure switches. It is not advisable to operate the boiler & its auxiliaries on / off mode. The power and fuel consumption will be more. It damages all the electrical switches. Further until the flame is established the fuel consumption will be more. It would be like operating your motorcycle in on/off mode. One customer experienced discoloration of rice due to high steam velocity resulting in stopping the boiler at higher pressure.

4.3. In the case of step grate uniform feeding over the grate is very important. I have seen in one case a slot is made in the floor so that a person goes on pushing the fuels uniformly over the width of the grate. The grate bars support and spacing should be proper. While raking the ash, many operators disturb the grate and this leads to nonuniform air gap between the grates. Once the gap is nonuniform, the poor combustion starts. One can observe the absence of the flame in many spots. The ash removal should be uniform. Uniform removal of ash leads to uniform climbing down of burning husk.

4.4. In flat grate the depth of the fuel bed should be uniform (about 2 inches) over the grate. If this is done one can think of good combustion in the furnace. The task is difficult. Pulsating grate / traveling grate / push grate would do a good job here. Both consume less power and ensure that the ash is discharged uniformly from the full width of the furnace. The choice of pulsating grate / traveling grate / push grate depends on the boiler capacity. The investment should justify the savings.

4.5. In Single pass shell type boiler, spring type spirals have been of nuisance as they get choked often. One can choose plate type turbulators shown in figure 6. These expose the heat transfer surface as well.

4.6. In general I find many are still continuing old horizontal model pumps. New range of vertical pumps is found to be saving good amount of power. While replacement of pumps one should certainly think of the vertical pump.

4.7. The POF boilers with fixed grate can be replaced by the Distributor plate. This ensures uniform airflow at all places. Thus the husk is burnt completely in suspension. The old type grate bars are shown in *Figure* 10. I recall that many times the grate bars would bend / disturbed. The husk used to accumulate over the grate in many placed and it called for the attention of Operators to clean up the furnace. With distributor plate the settling of ash in POF furnace is gone. The ID fan can be dispensed with thus there will be power saving.

4.8. Earlier days the POF furnaces were provided with a cyclone. The fuel used to be discharged like a spiral inside the furnace. The cross in the fuel drop chute has now eliminated the non-uniform spreading of fuel. In one case I observed that the pipe eroded off leading to leakage of steam. See *Figure* 7 showing the old tangential type fuel feed pipe. Figure 8 shows the cross type fuel feed pipe.

4.9. In one case the shell tubes were found to be eroding at the entry due to narrow design. Insertion of ferrules has given the relief against tube failure. *Figure* 11 shows a view of ferrule.

4.10. Rotary feeder below Mechanical dust collector is a must to improve the dust collection. One could use trema cyclone configuration would lead to better collection efficiency. Trema cyclone design employs optimum inlet velocity and long cone. *Figure* 12 shows the trema cyclone.

4.11. When ash dust emission was to be brought down in one case wet bottom gas duct with gas baffles were introduced to improve the ash settling.

4.12. Magnetic water conditioner is found to be effective in removing boiler scales. But then the softening needs to be continued. The scales were found to be completely removed when tried on a case where chemical cleaning had failed to do the cleaning.

4.13. Repeated tube failures were reported in one case. It was found the tubes were not fitted as per standard method. Tubes facing hot flue gases of temperatures above 650^{o}C are to be fitted as per weld figure shown in *Figure* 13.

5.0 CONCLUSION

There is good amount of options available for the rice mill industry to choose and specify the boiler depending on several factors such as the capacity, availability of alternate fuels, extent of automation, load response. While buying a boiler options have to be thoroughly seen. All the problems in the boiler are solvable. It is not necessary to live with a problem. I myself have seen some clients take initiatives to solve even small problems.