Studies on performance of the cogeneration programme in rice mills in West Bengal

Bijoy Kumar Majhi\textsuperscript{a}\textsuperscript,* , Tushar Jasha\textsuperscript{a}

\textsuperscript{a}School of Energy Studies, Jadavpur University, Kolkata 700032, India

Abstract

Gasifier based cogeneration power plants were installed in a large number of rice mills in West Bengal in India. The present study reports on performance of the rice mill cogeneration plants in the state. Viability of the programme has also been questioned in this paper.

© 2014 Bijoy Kumar Majhi. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/3.0/).

Selection and peer-review under responsibility of Organizing Committee of ICAER 2013

Keywords: Rice mills; husk; gasifier; cogeneration; viability.

1. Introduction

West Bengal is mainly an agricultural based state in India. The state covers a geographical area of 8,684,113 ha of which cultivated area is 4,991,222 ha [1]. There are 19 districts in West Bengal and out of these agriculture is the main economic activities in the 18 districts. Paddy is the major cultivated crop in the state. During processing of paddy to rice, besides rice bran, rice husk is generated as the main residue. Rice husk is traditionally used as a fuel in this area. Rice husk, like any other biomass, is used inefficiently in rural West Bengal. The rice husk is generally used for generating heat for the parboiling of paddy, often at efficiencies below 10% [2]. In recent times, rice husk is also used in industries as a boiler fuel in the state. But technologies are now available for generating electricity and heat from rice husk at relatively higher efficiencies. There are 2119 modern rice mills and about 36,000 number of

* Corresponding author. Tel.: +91-943-348-5110 .
E-mail address: bijoy119@gmail.com
rice hullers in West Bengal [3]. Most of the rice mills have capacity of processing 3 t of paddy per hour and majority of the rice hullers have capacity of 0.6 t per hour. During the period 2005 to 2009 an attempt was made by the Government of India to encourage the private rice mill owners to install rice husk based gasifiers in rice mills to generate electricity for own consumption in rice milling. Capital incentives in the form of financial subsides (15 to 33% depending on the plant size) were provided by the government to 76 rice mills in West Bengal to install rice husk based gasifiers. But the programme did not yield much success. Majority of the rice mill owners in the state which had installed rice husk based gasifiers in their mills dismantled the systems and switched over to utility-supplied electricity to run their mills. No study appears to have been reported regarding the actual reasons behind the failure of the gasifiers installed in rice mills in West Bengal. Contrary to that a number of private power producers have come forward to install small capacity grid connected biomass based power plants (Rankine cycle) for electricity generation in recent years. The first such power plant of 10 MW capacity has been installed and commissioned in Bankura district of the state in 2009. These power plants are fueled by rice husk purchased from rice mills. So, apart from the traditional demand for rice husk, a new market has been created for rice husk and the price of rice husk has also increased in recent years in West Bengal. Under this circumstance the rice mill owners may find it profitable to sell their surplus rice husk to the power plants instead of using it in their own gasifiers for captive power generation. No study has been reported investigating these issues. For this reason, it was decided to investigate the reasons behind the failure of rice husk based gasifiers for power generation in rice mills in West Bengal. The objectives of the present study were: (1) to find out the reasons behind the dismantling of rice husk based gasifiers installed in a large number of rice mills in the state; (2) to investigate whether the failure of the programme was solely due to economic reasons or due to relatively complex nature of technology of biomass gasification and poor reliability of the gas cleaning systems.

2. Methodology and data source

Data sources were empirical as well as collected from secondary sources. A primary level field survey was conducted on rice mills in Hooghly and Burdwan district in West Bengal to collect information on the capacity of the mill, the capacity of the gasifier installed in the rice mill, cost of installation of the gasifier and the amount of subsidy provided by the government, hours of operation of the mill and the gasifier, frequency of maintenance, type of failures, labor charges, diesel replacement, and electricity consumption. Information on the amount of paddy milled per year, rice husk generation, own consumption of rice husk with or without the gasifier in the rice mill and annual surplus availability were also collected by physically visiting the mills. The study has been carried out by filling up structured questionnaire during the field survey. About 10% of the total rice mills in the state, where gasifiers were installed have been selected for the study. The selection was made by random sampling method. Hooghly and Burdwan district were selected because majority of the rice mills in West Bengal are situated in these districts.

3. Modern rice mill at a glance

In modern rice mills the following steps are involved (Fig. 1). First, the paddy is cleaned. Next step is parboiling, where cleaned paddy is soaked in hot water to increase its moisture content to about 30%. Immediately after the soak tanks, the paddy is steam cooked (parboiled) to gelatinized the starch in the grain and the moisture content of the rice becomes 35%. In the parboiling step steam is used. After steam cooling, the rice is dried to reduce the moisture content to about 12% before it is sent for milling. In the drier both steam and electricity are used. Next step is milling and polishing. Milling involves removal of the outer husk from the inner kernel and thus, separation of paddy into husk and brown rice. Then, the bran is removed from the brown rice to produce white rice or milled rice. Rice husk and bran are generated at this stage as byproducts. For this step, mechanical rolling power is required and mostly electricity or diesel is used as energy source.
4. Cogeneration programme in rice mill in west bengal

Parboiling operation, in a modern rice mill, mainly requires thermal energy supplied by steam. Electricity is largely required in the milling and polishing section for providing the motive power. Steam is generated through combustion of the rice husk produced. It has been estimated that about 60% of the rice husk produced, during processing of paddy, is consumed in a rice mill for steam generation and 40% of the rice husk remains surplus. In cogeneration project in rice mills, this surplus rice husk is used in gasifier for captive power generation. During 2005 to 2009, rice husk based gasifiers were installed for captive power generation in 76 rice mills in West Bengal. Capacity of the gasifiers varied from 40 KW to 350 KW, but most of the gasifiers were 175 KW, 200 KW or 250 KW. They were all fluidized bed gasifiers. District wise installation of gasifiers in rice mills in West Bengal are given in Table 1. It shows that the maximum number of gasifiers were installed in Burdwan district and the cumulative capacity of rice husk based gasifiers in rice mills in the state was 14.76 MW.

<table>
<thead>
<tr>
<th>Sl no.</th>
<th>Installation zones</th>
<th>Number of rice mills installed gasifiers</th>
<th>Capacities of gasifier kW (Number)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Burdwan district</td>
<td>56</td>
<td>40(1), 120(2), 150(8), 175(15), 200(16), 250(10), 300(3), 350(1)</td>
</tr>
<tr>
<td>2</td>
<td>Hooghly district</td>
<td>12</td>
<td>120(1), 150(4), 200(4), 250(2), 350(1)</td>
</tr>
<tr>
<td>3</td>
<td>Bankura district</td>
<td>2</td>
<td>120(1), 175(1)</td>
</tr>
<tr>
<td>4</td>
<td>Midnapore district</td>
<td>2</td>
<td>175(2)</td>
</tr>
<tr>
<td>5</td>
<td>Murshidabad district</td>
<td>1</td>
<td>175(1)</td>
</tr>
<tr>
<td>6</td>
<td>Birbhum district</td>
<td>3</td>
<td>120(1), 200(2)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>76</td>
<td>14765</td>
</tr>
</tbody>
</table>

5. Performance of the gasifier based captive power plants in rice mills

A survey has been conducted, during 2012-13, to evaluate the performance of rice husk based gasifiers installed in rice mills in West Bengal. Eight rice mills which had installed gasifier based captive power plants have been selected for this study. By physical verification it has been found that all the 8 rice mills dismantled the gasifiers and have switched over to utility supplied electricity to run the mills. The gasifiers were in operation for 1½ year to 2 years after commissioning of the plants. Information gathered through personal interview with the rice mill owners and the operators regarding failure of gasifier projects in their rice mills are discussed here. Rice husk and diesel consumption data were collected from the daily log books of the rice mills. It has been observed that there was a
wide variation in percentage of diesel replacement by the gasifiers among the rice mills. The diesel replacement varied from 25 to 72% of the total requirement if the rice mills would run by diesel only (Table 2). Although the manufacturers of gasifier in India claimed a diesel substitution of over 75%, but in most of the cases the actual level of diesel replacement has been found lower. Average consumption of rice husk per kWh of electricity generation has been estimated as 1.5 kg.

Table 2 shows that when the rice mills were run by gasifiers, the energy expenditure per tonne of paddy processed varied from Rs. 141 to Rs. 300. In Table 2, daily expenditure for gasifier operation have been estimated by deducting the market price of surplus rice husk (income from selling of the remaining husk) from the operational cost of the gasifier per day which includes the cost of rice husk consumed in the gasifier, cost of diesel, additional labor charges and maintenance charge. Market price of rice husk was taken as Rs. 2000 per tonne. Daily maintenance charge has been estimated by dividing the annual maintenance charge of the gasifier and the engine with the total number of operational days of the rice mills per year (300 days).

Energy expenditure (per day) for operating the rice mills run by diesel engines have been estimated and given in Table 3. In this case the energy expenditure per tonne of paddy processed varies from Rs. 125 to Rs. 200 which is lower for most of the rice mills when compared with the energy expenditure of the mills run by gasifiers (Table 2).

All the surveyed rice mills which had installed gasifiers, dismantled the system and have switched over to electricity supplied by the state electricity board. At present, they depend completely on the utility supplied electricity to get the motive power. Energy cost, in the present situation, per tonne of paddy processed have been estimated (Table 4) and it varies from Rs. 79 to Rs. 117 which are least for all the rice mills compared to the previous two cases (Table 2 and Table 3).

5.1. Technical problem faced with the gasifier based cogeneration plant in rice mills

In general, all the rice mill owners and the operators have complained that the operation of the gasifier was troublesome and the diesel replacement was low. In particular, the fresh water demand for the gas cleaning and cooling system and the amount of contaminated water discharged by the power generating system were both quite high. The reliability of the gas cleaning system has also been questioned by the mill operators. There were complaints on frequent choking of the gas pipelines and engine overheating. Other than these, the mill owners faced labor problem due to the gasifiers. In a few cases the laborers refused to work, especially when there was incident of gas leakage. The owners were also not happy with the gasifier power plants due to its higher maintenance cost compared to diesel engines or electric drives.

6. Conclusions

The present study reveals that the cogeneration programme in rice mills for captive power generation, in West Bengal, did not yield success. (2) In most of the rice mills where rice husk based gasifier were installed, they ran the gasifiers for about 1 1/2 year to 2 years and then dismantled the systems. All the rice mills have switched over to electricity supplied by the utility. (3) The study also reveals that the reason behind dismantling the gasifiers and opting for utility supplied electricity is purely economic. (4) As there exists a good market for rice husk in West Bengal the rice mill owners have found it profitable to sell the surplus rice husk in the open market rather than using it in gasifier for captive power generation. The present study reveals that the energy cost per tonne of paddy processed is least when the rice mills purchase electricity from the utility provided there exists a market for rice husk and the selling price of husk is reasonably high. (5) Secondly, due to tardy progress of industrialization there is excess power generation in the state in the recent years. It has become easier for the rice mills to get electricity connections from the state electricity board. (6) So far the demand for large amount of fresh water and the discharge of contaminated water are concerned, these problems can be solved by replacing the wet cooling systems with dry cooling systems or by installing an effluent treatment plant within the rice mills [4]. (7) The problem of engine overheating can be solved if 100% gasifier gas based engines are used. But the success of the cogeneration programme in rice mills entirely depends on the economic viability of the project. There then arises the question whether the government should provide financial subsidies on such a programme.
Table 2. Performance data of rice mills run by gasifiers.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the rice mill</th>
<th>Capacity of the mill (t/h)</th>
<th>Paddy processed (t/d)</th>
<th>Capacity of the gasifier (kW)</th>
<th>Surplus rice husk generated (t/d)</th>
<th>Rice husk consumed by the gasifier (t/d)</th>
<th>Cost of husk if it is sold in the market (Rs.)</th>
<th>Income from selling of the remaining husk (Rs./d)</th>
<th>Diesel consumption (l/d)</th>
<th>Energy cost for diesel (Rs./d)</th>
<th>Additional labor charge (Rs./d)</th>
<th>Maintenance cost for gasifier &amp; engine (Rs./d)</th>
<th>Daily expenditure for gasifier operation (Rs./d)</th>
<th>Expenditure for energy/tonne of paddy processed (Rs./t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bhoroshar rice mill</td>
<td>3 x 2</td>
<td>96</td>
<td>200</td>
<td>8</td>
<td>4.8</td>
<td>9600</td>
<td>3.2</td>
<td>6400</td>
<td>176</td>
<td>9630</td>
<td>500</td>
<td>400</td>
<td>13730</td>
</tr>
<tr>
<td>2</td>
<td>Panchanan rice mill</td>
<td>3 x 2</td>
<td>108</td>
<td>250</td>
<td>9</td>
<td>6.75</td>
<td>13500</td>
<td>2.25</td>
<td>4500</td>
<td>216</td>
<td>11785</td>
<td>500</td>
<td>300</td>
<td>21585</td>
</tr>
<tr>
<td>3</td>
<td>Jyotish rice mill</td>
<td>3</td>
<td>24</td>
<td>200</td>
<td>2</td>
<td>2</td>
<td>4000</td>
<td>0</td>
<td>0</td>
<td>48</td>
<td>2619</td>
<td>300</td>
<td>400</td>
<td>7319</td>
</tr>
<tr>
<td>4</td>
<td>Joyrampur rice mill</td>
<td>3</td>
<td>48</td>
<td>140</td>
<td>4</td>
<td>3.36</td>
<td>6720</td>
<td>0.64</td>
<td>1280</td>
<td>128</td>
<td>6984</td>
<td>400</td>
<td>200</td>
<td>13024</td>
</tr>
<tr>
<td>5</td>
<td>Lalji rice mill</td>
<td>3</td>
<td>48</td>
<td>120</td>
<td>4</td>
<td>2.88</td>
<td>5760</td>
<td>1.12</td>
<td>2240</td>
<td>96</td>
<td>5238</td>
<td>500</td>
<td>400</td>
<td>9658</td>
</tr>
<tr>
<td>6</td>
<td>Balai agro industries</td>
<td>3</td>
<td>24</td>
<td>175</td>
<td>2</td>
<td>2</td>
<td>4000</td>
<td>0</td>
<td>0</td>
<td>48</td>
<td>2619</td>
<td>300</td>
<td>300</td>
<td>7219</td>
</tr>
<tr>
<td>7</td>
<td>Shree rice mill</td>
<td>3</td>
<td>48</td>
<td>250</td>
<td>4</td>
<td>3.75</td>
<td>7500</td>
<td>0.25</td>
<td>560</td>
<td>100</td>
<td>5456</td>
<td>300</td>
<td>300</td>
<td>12996</td>
</tr>
<tr>
<td>8</td>
<td>Surjyakanta rice mill</td>
<td>3 x 2</td>
<td>96</td>
<td>250</td>
<td>8</td>
<td>6</td>
<td>12000</td>
<td>2</td>
<td>4000</td>
<td>160</td>
<td>8730</td>
<td>500</td>
<td>300</td>
<td>17530</td>
</tr>
</tbody>
</table>

(i) Diesel price: Rs. 54.56 per litre; (ii) selling price of rice husk: Rs.2000 per tonne.
Table 3. Energy consumption data of rice mills when run by diesel engines.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the rice mill</th>
<th>Capacity of the mill (t/h)</th>
<th>Paddy processed (t/d)</th>
<th>Surplus rice husk generated (t/d)</th>
<th>Income from selling of surplus husk (Rs./d)</th>
<th>Diesel consumption (l/d)</th>
<th>Energy cost for diesel (Rs./d)</th>
<th>Maintenance cost for engine (Rs./d)</th>
<th>Total expenditure (Rs./d)</th>
<th>Expenditure for energy / tonne of paddy processed (Rs./t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bhorosha rice mill</td>
<td>3 x 2</td>
<td>96</td>
<td>8</td>
<td>16000</td>
<td>576</td>
<td>31427</td>
<td>170</td>
<td>15597</td>
<td>162</td>
</tr>
<tr>
<td>2</td>
<td>Panchanan rice mill</td>
<td>3 x 2</td>
<td>108</td>
<td>9</td>
<td>18000</td>
<td>648</td>
<td>35355</td>
<td>170</td>
<td>17525</td>
<td>162</td>
</tr>
<tr>
<td>3</td>
<td>Jyotish rice mill</td>
<td>3</td>
<td>24</td>
<td>2</td>
<td>4000</td>
<td>160</td>
<td>8730</td>
<td>120</td>
<td>4850</td>
<td>202</td>
</tr>
<tr>
<td>4</td>
<td>Joyrampur rice mill</td>
<td>3</td>
<td>48</td>
<td>4</td>
<td>8000</td>
<td>256</td>
<td>13967</td>
<td>150</td>
<td>6117</td>
<td>127</td>
</tr>
<tr>
<td>5</td>
<td>Lalji rice mill</td>
<td>3</td>
<td>48</td>
<td>4</td>
<td>8000</td>
<td>288</td>
<td>15713</td>
<td>150</td>
<td>7863</td>
<td>164</td>
</tr>
<tr>
<td>6</td>
<td>Balai agro industries</td>
<td>3</td>
<td>24</td>
<td>2</td>
<td>4000</td>
<td>144</td>
<td>7857</td>
<td>150</td>
<td>4007</td>
<td>167</td>
</tr>
<tr>
<td>7</td>
<td>Shree ma rice mill</td>
<td>3</td>
<td>48</td>
<td>4</td>
<td>8000</td>
<td>320</td>
<td>17459</td>
<td>140</td>
<td>9599</td>
<td>200</td>
</tr>
<tr>
<td>8</td>
<td>Surjyakanta rice mill</td>
<td>3 x 2</td>
<td>96</td>
<td>8</td>
<td>16000</td>
<td>512</td>
<td>27935</td>
<td>170</td>
<td>12105</td>
<td>126</td>
</tr>
</tbody>
</table>

(i) Diesel price: Rs. 54.56 per litre; (ii) selling price of rice husk: Rs.2000 per tonne.

Table 4. Performance data of rice mills run by electricity.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the rice mill</th>
<th>Capacity of the mill (t/h)</th>
<th>Paddy processed (t/d)</th>
<th>Surplus rice husk generated (t/d)</th>
<th>Average monthly electricity bill (Rs.)</th>
<th>Daily electricity cost (Rs./d)</th>
<th>Maintenance cost for the electric drives (Rs./d)</th>
<th>Income from selling of surplus husk (Rs./d)</th>
<th>Total expenditure (Rs./d)</th>
<th>Expenditure for energy / tonne of paddy processed (Rs./t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bhorosha rice mill</td>
<td>3 x 2</td>
<td>96</td>
<td>8</td>
<td>7600000</td>
<td>25333</td>
<td>150</td>
<td>16000</td>
<td>9483</td>
<td>99</td>
</tr>
<tr>
<td>2</td>
<td>Panchanan rice mill</td>
<td>3 x 2</td>
<td>108</td>
<td>9</td>
<td>8000000</td>
<td>26664</td>
<td>150</td>
<td>18000</td>
<td>8814</td>
<td>82</td>
</tr>
<tr>
<td>3</td>
<td>Jyotish rice mill</td>
<td>3</td>
<td>24</td>
<td>2</td>
<td>1800000</td>
<td>6000</td>
<td>110</td>
<td>4000</td>
<td>2110</td>
<td>88</td>
</tr>
<tr>
<td>4</td>
<td>Joyrampur rice mill</td>
<td>3</td>
<td>48</td>
<td>4</td>
<td>3500000</td>
<td>11667</td>
<td>135</td>
<td>8000</td>
<td>3802</td>
<td>79</td>
</tr>
<tr>
<td>5</td>
<td>Lalji rice mill</td>
<td>3</td>
<td>48</td>
<td>4</td>
<td>3600000</td>
<td>12000</td>
<td>150</td>
<td>8000</td>
<td>4150</td>
<td>86</td>
</tr>
<tr>
<td>6</td>
<td>Balai agro industries</td>
<td>3</td>
<td>24</td>
<td>2</td>
<td>2000000</td>
<td>6667</td>
<td>130</td>
<td>4000</td>
<td>2797</td>
<td>117</td>
</tr>
<tr>
<td>7</td>
<td>Shree ma rice mill</td>
<td>3</td>
<td>48</td>
<td>4</td>
<td>3500000</td>
<td>11667</td>
<td>120</td>
<td>8000</td>
<td>3787</td>
<td>79</td>
</tr>
<tr>
<td>8</td>
<td>Surjyakanta rice mill</td>
<td>3 x 2</td>
<td>96</td>
<td>8</td>
<td>7500000</td>
<td>25000</td>
<td>150</td>
<td>16000</td>
<td>9150</td>
<td>95</td>
</tr>
</tbody>
</table>

(i) Selling price of rice husk: Rs.2000 per tonne.

References