Rice husk, its application, power generation & environmental impact – An overview

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ABSTRACT

India is a major rice producing country, and its one of the state Chhattisgarh is known as Bowl of rice. The husk from after milling is great in amount and it seems un useful in rural area but its application comes in a picture in current world like the husk generated during milling is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion. Rice Husk Ash (RHA) is a great environment threat causing damage to the land and the surrounding area in which it is dumped. So its application as in bricks making may help to save land and similar other application of rice husk or its ash as well as its way to electricity production is discussed here.

Keywords: Rice Husk, Rice Husk Ash, financial feasibility, electricity production, rice husk property.

1. INTRODUCTION

Rice husk generated as a by-product of rice processing is an important energy resource. The Availability of this resource in India has been assessed and the technologies for exploitation of its energy potential in rice processing industry discussed. Nomographs have been developed for estimation of the husk required to meet the energy demand of parboiling, drying and milling operations. Rice is a major cereal in India accounting for about 40% of food grain production and over 30% of its cropped area. India’s share in world rice production is 21%. Rice is the edible form of paddy (also known as rough rice) and in the process of conversion from paddy, rice husk and rice bran are generated as by-products. While rice bran is used for oil extraction and in feed formulations, the husk is generally used as a fuel, for generating heat for the parboiling of paddy or other applications, often at efficiencies below 10%. Surplus husk has many applications, mainly in tobacco curing operations and brick kilns, but include production of furfural, cement, boards etc. Use of husk in industries other than rice processing involves handling and transportation of this low bulk density (112-144 kg/m3) by-product. On-site use of husk in the rice processing industry, which needs energy in both thermal and mechanical forms, avoids the necessity of transportation. Technologies for conversion of husk into electricity and thermal energy at relatively higher efficiencies are now available.3, 4 The present work is an attempt at assessing the financial feasibility of using rice husk as an energy source to meet on-site electrical and/or thermal energy requirements of a rice processing industry. Since there are several technological problems yet to be resolved.
before the rice husk gasifier dual fuel engine-generator systems could be considered an appropriate technological alternative to grid electricity or diesel generator sets in India, the primary objective of the present work is to present a systematic methodology for financial feasibility evaluation of such systems. In fact the values of the various input parameters (like costs/efficiencies etc. of the energy conversion equipment) used may be considered as indicative only. With more authentic input data availability in near future, the methodology presented in this work could be used to arrive at specific realistic conclusions.

Despite the increasing trend of the rice husk surplus, proper methods of its utilization have yet to be developed. Today, most of the surplus rice husks is disposed by direct burning in open heaps, which results in loss of energy as well as emission of various pollutants to the atmosphere. However, many countries have imposed new regulations to restrict burning of rice husks, primarily for environmental reasons. Consequently, this increased the interest in the utilization of rice husks as a renewable source of energy [2±5]. Ghaly et al. as an alternative to combustion or low density biomass materials. One of the important features of gasification is that the reaction temperature can be kept as low as 600±6508C, thereby preventing sintering and agglomeration of the ash which causes serious operational problems during the combustion process.

Ergudenler et al. fluidized bed technology offers great advantages when used for gasifying low calorific value fuels such as rice husks. It has the advantage of being small in size, requiring relatively low capital investment, and can be easily automated to minimize the use of full time operating labor. The system exhibits high thermal conversion efficiency, produces high quality low heating value gas with very small amounts of condensable tars and the ash resulting from it is subjected to high temperature and may be automatically collected and discharged. The gas produced can be used to operate spark and diesel engines or gas turbines to generate power.

2 RICE PRODUCTIONS

Paddy rice (Oryza sativa) is grown on every continent except Antarctica and the extent of paddy cultivation covers about 1 percent of the earth’s surface. More than half of the world’s population depends on rice as a staple food and it ranks second to wheat in terms of cultivation area and production. The quantum of global production of paddy is close to 650 million tons per annum [www.maps of world.com]. Production of rice is dominated by Asia, where rice is the only food crop that can be grown during the rainy season in the waterlogged tropical areas. Asia generates over 90 percent of world rice production (Table 2.1). Together, China and India accounted for over half of the world’s rice supply [www.maps of world.com]. In India, Tamil Nadu is the third ranking state in the production of paddy after Andhra Pradesh and West Bengal. Paddy production is nearly 7 million tons in Tamil Nadu [www.maps of world.com]. Paddy, on an average, consists of about 72 percent of rice, 5-8 percent of bran, and 20-22 percent of husk [Prasad et al., 2000]. Of all the plant residues, the ash of rice husk contains the highest proportion of silica. It is estimated that every tons of paddy produces about 0.20 tons of husk and every tons of husk produces about 0.18 to 0.20 tons of ash, depending on the variety, climatic conditions and geographical. The
total global ash production could be as high as about 23 million tons per year.

2.1 Properties of Rice Husk
Rice husk is a potential material, which is amenable for value addition. The usage of rice husk either in its raw form or in ash form is many. Most of the husk from the milling is either burnt or dumped as waste in open fields and a small amount is used as fuel for boilers, electricity generation, bulking agents for composting of animal manure, etc.. The exterior of rice husk are composed of dentate rectangular elements, which themselves are composed mostly of silica coated with a thick cuticle and surface hairs. The mid region and inner epidermis contain little silica. Jauberthie et al., (2000) confirmed that the presence of amorphous silica is concentrated at the surfaces of the rice husk and not within the husk itself. The chemical composition of rice husk is similar to that of many common organic fibers and it contains of cellulose 40-50 percent, lignin 25-30 percent, ash 15-20 percent and moisture 8-15 percent [Hwang and Chandra, 1997]. After burning, most evaporable components are slowly lost and the silicates are left. The typical properties of rice husk are indicated in Table 2.2. No other plant except paddy husk is able to retain such a huge proportion of silica in it. Plants absorb various minerals and silicates from earth into their body. Inorganic materials, especially silicates are found in higher proportions in annually grown plants, such as rice, wheat, sunflower, etc. than in long-lived trees.

Table 1: Typical husk analysis [Bronzeoak, 2003]

<table>
<thead>
<tr>
<th>S. No</th>
<th>Property</th>
<th>Range</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Bulk density (kg/m3)</td>
<td>96 - 160</td>
</tr>
<tr>
<td>2.</td>
<td>Length of husk (mm)</td>
<td>2.0 – 5.0</td>
</tr>
<tr>
<td>3.</td>
<td>Hardness (Mohr’s)</td>
<td>5.0 - 6.0</td>
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3. RESOURCE AVAILABILITY
The availability of husk depends on the paddy production, its proportion processed into rice and the fraction of husk in paddy. Total energy potential would depend upon its calorific value as well as the quantity available. Annual paddy production in the country can be estimated from the area under the crop and its average productivity. These two parameters depend on several independent and interrelated

3.1. Variations in husk availability
3.1.1. Geographical distribution. Paddy is cultivated in almost all the states of India. However, Andhra Pradesh, West Bengal, Uttar Pradesh and Punjab are the leading states in that order and account for nearly 50% of production. State wise availability of husk was assessed on the basis of paddy production and its fraction processed into rice.

3.1.2. Seasonal distribution. Paddy is cultivated mainly in the kharif season (July-October), which accounts for 92-94% of annual gross cropped area under paddy and 8690% of gross annual production. The average productivity of paddy during the rabi season (November-April) is over 1.5 times that of kharif, probably because most of the area during the rabi season is irrigated. Processing of paddy, in general, for conversion into rice is also a seasonal activity (November-April) in most parts of the country. However, in areas where two
crops are taken, it continues almost round the year.

3.1.3. Rice mill. At the level of an individual rice mill, the annual availability of husk and its energy potential depend on the capacity of the rice mill, annual hours of operation, HPR of paddy and CV of the husk generated. For a typical one tons per hour (t/h) rice mill operating 2400 h a year the available energy potential works out to be 6.4 TJ for an HPR of 0.2 and assuming a CV of 13.4 MJ/kg for the husk.

4. ENERGY DEMAND FOR RICE PROCESSING

Rice processing mainly includes paddy parboiling (if undertaken), its drying and milling. Paddy milled without parboiling produces raw rice (also called white rice). Otherwise, the product is called parboiled rice. Parboiling and drying operations largely require thermal energy whereas milling requires motive power which is generally provided through electric motor drives. Some electricity may also be used in material handling operations during parboiling and drying. For milling, mainly three types of systems, huller, sheller and modern rice units, are used. Electrical energy intensities vary for raw and parboiled rice in these three milling systems.

5. APPLICATON OF RICE HUSK

5.1 As a Fuel in Power Plant

Rice husk is mostly used as fuel in boilers for processing paddy and generation of process steam. Heat energy is produced through direct combustion and/or by gasification. Small sector process industries use fixed low capacity boilers, which are manually fired using rice husk as a fuel. Partial and uneven fuel combustion lead to smoke emission and decrease the fuel efficiency. As husks are available virtually for free, the boiler efficiency and the degree of combustion were the issues of receiving the latest attention. Plants with capacity 2-10 MW range can become commercially viable and this biomass resource can be utilized to a much greater extent than at present. It has been seen that to produce 1MWh, approximately 1 tonne of rice husk is required.

5.2 Formation of Activated Carbon

Due to presence of large amount of hydrocarbon such as cellulose and lignin content, rice husk can be used as a raw material to prepare activated carbons which are complex porous structures. They are obtained by two different processes: the physical or thermal activation and the chemical activation. In the former carbonization is followed by char activation; in the second one, carbonization and activation are performed in a single step, using a chemical agent. Physical activation of rice husk produces activated carbon that exhibits very low specific area. Activated carbons are effective adsorbents due to their micro porous structure.

5.3 As a source of Silica and Silicon Compounds

Apart from organic component, presence of up to 20% silica makes rice husk a promising raw material source for a number of silicon compounds such as silicon carbide, silicon nitride, silicon tetrachloride, zeolite, silica, and pure silicon. The applications of such materials derived from rice husks are very comprehensive. The above compounds prepared in powder form are characterized by high purity and fine disparity.
6 APPLICATIONS OF RICE HUSK ASH

RHA has got numerous applications in silicon based industries. Substantial research has been carried out on the use of RHA as a mineral admixture in the manufacture of concrete. RHA in amorphous form can be used as a partial substitute for Portland cement and as an admixture in high strength and high performance concretes.

- Manufacture of Rice Husk Ash

Rice husk ash is produced by burning the outer shell of the paddy that comes out as a waste product during milling of rice. Since they are bulky disposal of husk present an enormous problem. Each ton of paddy produces about 200kg of husk and this rice husk can be effectively converted through controlled burning. At around 500ºC a valuable siliceous product that can enhance the durability of concrete in the chemical composition of rice husk ash is obtained. Variations in the burning temperature much above or below will drastically alter the silica content of the ash. It is estimated that one fifth of the five hundred million tons of world annual paddy production is available as rice husks. Only a small quantity of rice husk is used in agricultural field as a fertilizer, or as bedding etc. and stabilization of black cotton soils. The manufacture and batching of Rice husk Ash involves bulk handling of a light raw material and proper and a controlled burning methodology has to be adopted. Grinding of the ash is done after necessary cooling and can be done to any desired fineness. The author manufactures RHA and adopts a fineness value of around 4200blaine. There is another difficulty in the manufacturing of RHA. Namely burning of the raw husk to a high temperature for a sustained period makes it extremely difficult to cool the ash to normal temperature. This is also compounded by the inherent nature of raw husk to retain heat for a considerably long time. Therefore the method adopted is to allow the burnt husk to stay for some time and subsequently cool with water. However, when this is done the Ash is saturated with moisture and therefore grinding becomes a challenging task–especially with an abrasive material like RHA. Therefore drying of RHA is a must. Among the several methods that are possible normal sun drying and / or drying using paddy driers are the cheapest options. Another point to be borne in mind is the variation in the raw material composition from different sources and therefore the material has to be tested for chemical composition.

6.1 Concrete with Rice Husk Ash

However the durability enhancement properties of RICE HUSK ASH when blended with cement makes it the most eco-friendly versatile supplementary cementing material to concrete. The following properties of concrete are considerably altered when blended with RHA:

1. Reduced heat of hydration – leading to minimal crack formation in higher grades of concrete.
2. Reduced permeability at higher dosages.
3. Increased chloride and sulphate resistance/mild acids.

Therefore RHA can be used as an effective and Green supplementary cementing material.

6.2 Other applications

Basha, et al examined the possibilities of improving residual soil properties by mixing RHA and cement in suitable proportions as stabilizing agents. Indian Space Research Organization has successfully developed a technology for producing high purity silica

Available online: http://internationaljournalofresearch.org/
from RHA that can be used in manufacturing of silicon chip in industry ref. 

Saha, et al studied the possibility of using RHA in water purification. Attempts have been made to utilize RHA in vulcanizing rubber.

H Ismail et al studied use of Rice Husk to synthesize High-Performance Phosphors. Other uses of RH are in control of insect pests in Stored Food Stuffs, in the water purification, in vulcanizing rubber, as flue gas desulphurization absorbents. RHA has been found to be effective as an oil spill absorbent, and for use in waterproofing chemicals, flame retardants, and as a carrier for pesticides and insecticides. Its absorbent and insulating properties are useful to many industrial applications.

7 ELECTRICITY GENERATIONS BY RICE HUSK

The unit cost of electricity using rice husk gasifier-based power generation systems has been calculated and its financial feasibility assessed in comparison with utility-supplied and diesel-generated electricity. With the cost and efficiency data assumed here, the unit cost of electricity produced by rice husk gasifier-dual fuel engine-generator system varies between Rs 5/kWh and Rs 7/kWh. (Note: 35 Rs approximates to $US 1.)

Its production of electricity is as similar as other plants only here we use rice husk in place of coal. Its pre heating is required in rainy days usually; its amount is higher to generate same kw power due to low calorific value of rice husk.

Fig:1 schematic diagram of rice husk based power plant

8. ENVIRONMENTAL AND SOCIAL IMPACTS

1. Husk Power Systems are cost effective and can provide reliable, and affordable electricity to rural population.
2. Husk Power generates electricity from rice husks, avoiding the use of fossil fuels. The use of rice husks for fuel does not create competition with food crops since the rice husks would otherwise be agricultural waste.
3. Power transmission may be done through insulated wires upto maximum distance of 2 km to avoid voltage loss. Locally available bamboo posts can be utilised very effectively to support the transmission wires.
4. No pre-experienced technicians would be required but can be locally trained to operate the plant once units are set up thereby creating opportunities for employment.
5. The power delivery system could be completely decentralised i.e run and maintained by the locals where the plants are installed.
6. Project Implementing Agency (PIA) can be a partner in the Clean Development Mechanism (CDM) program so that the Power Plant can sell carbon credits for the emissions reduced by the plants. (i.e
abandoning fossil fuel run generators by
gasifying the husks thereby preventing the
release of a considerable amount of methane
gas, one of the world's most potent
greenhouse gasses.)

CONCLUSION
The production of rice is in massive amount
in India. As is disposal is a prime focus of
our study here we discussed its uses as direct
combustion and after combustion it forms
ash, RHA contributes significantly to a
green building. It not only reduces the
consumption of cement due
to blending but also solves the waste
disposal problem. Rice husk ash therefore
can be effectively used as a sustainable
concrete option in severe environments
and can be considered a class apart from all
other mineral admixtures due to its unique
microstructure and the resultant benefits in
concrete and its multi various application
possibilities. Apart from all of these it is
economical and a nice way of utilization of
waste in energy.

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