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Understanding rice husk as a biomass fuel

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Rice husk as a biomass fuel

Rice husk is a by-product of rice growing. The prevalence and year-round production of rice crops on both an industrial and small scale means that rice husks are an attractive biomass fuel because they are not only readily available in large quantities but are also easy to collect. Furthermore, combusting the husk solves the problem of waste husk disposal. Husk-based power plants have the potential to be not only viable, but highly profitable, provided that the fuel properties are well understood and that the fuel is combusted using equipment which is specifically designed, and therefore enables cost effective exploitation.

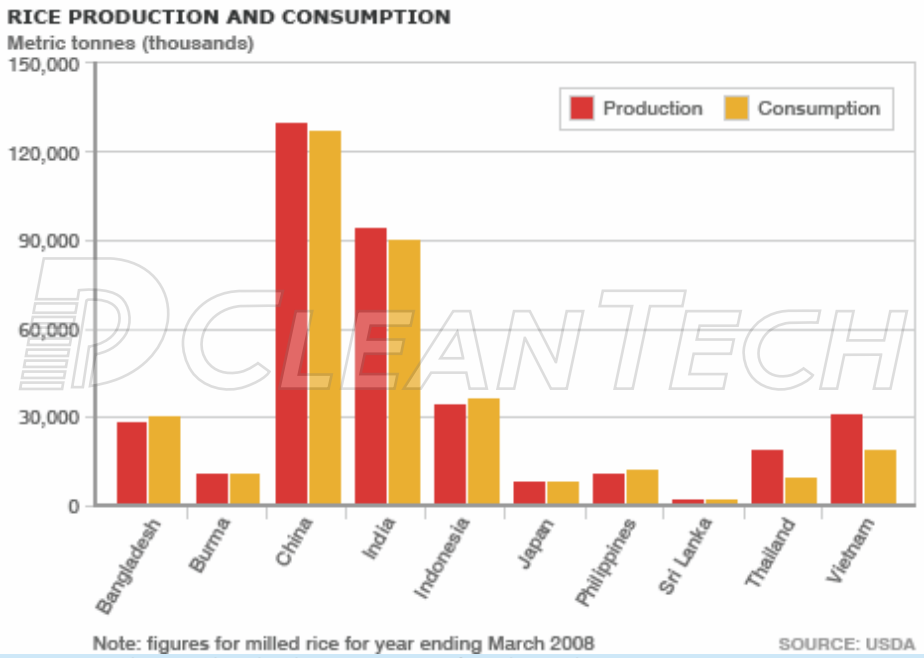
Origins of rice husk as a fuel

Rice husk has been used as a fuel to provide power for more than 100 years. The first recorded use of rice husk as an energy source was in 1889, in Myanmar. In the late 20th century rice husk's potential as a fuel was recognized around the world, particularly in developing countries. In 1971, UNFAO stated that rice husk would become a key fuel resource in the foreseeable future. However, small scale rice husk boilers were never properly commercialized until recently due to immature combustion technology which could address the specific needs of rice husk combustion. Today, rice husk, if properly combusted, is one of the most successful and profitable renewable energy sources available.

Rice husk in Asia

Asia produces the vast majority of global rice at around 770 million tons annually. 20% of the rice weight can be attributed to the husk or hull which is not consumed and often disposed of. This equates to 150 million tons of biomass fuel annually. Put into context, this could, for example, potentially add 22 GW of renewable installed capacity to Asia's energy mix.

Some of the top producers are illustrated below:



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Rice husk ash

An additional benefit of using rice husk as a biomass fuel is from the ash after the rice husk has been combusted. The Rice Husk Ash (abbreviated to RHA), is particularly high in silica (Si). Silica is an important raw material for many purposes, and RHA is therefore becoming increasingly valuable. Some of the uses of Silica are identified below:

- Aggregates and fillers for concrete and board production.
- Economical substitute for microsilica / silica fumes
- Absorbents for oils and chemicals
- Soil ameliorants
- Source of silicon
- Insulation powder in steel mills
- Repellents in the form of "vinegar-tar"
- Release agent in the ceramics industry
- Insulation material for homes and refrigerants

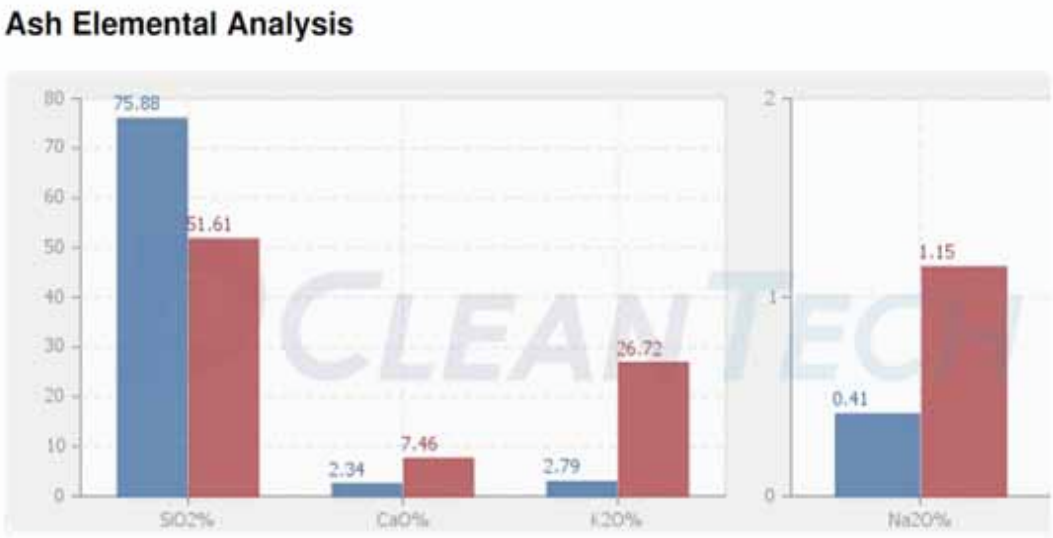
How does rice husk fare under combustion, and what are the key challenges?

Combustion: Rice husk has a very favourable chemical composition

Compared to many other biomass fuels - particularly the more herbaceous biomass fuels such as rice straw - rice husk causes relatively low amount of corrosion, fouling and sintering. It is therefore a comparatively unproblematic fuel.

The composition of the RHA and the reactions that can take place in the combustion chamber and on boiler tubes are major contributory factors to the level of sintering, slagging, fouling and corrosion. It is therefore very important that ash elemental analysis; a good knowledge of ash composition, and the impact these have on the boiler at high temperatures and pressures are taken into account in the initial boiler design.

The most influential chemical components of ash which affect the ash fusion temperature are silicon dioxide (SiO2), potassium oxide (K2O), sodium oxide (Na2O) and calcium oxide (CaO). The following graph taken from DP Biomass Lab demonstrates how this can differ depending on region and rice variety.



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Blue: Rice Husk - Pakistan

Red: Rice Straw - India

- Rice husk typically has ash contents from 15–25 w-% in dry solids, which is higher than many other biomass fuels.
- Rice husk can be characterized as a biomass rich in Si, but poor in Ca, K. The analysis indicates SiO_2 of over 75%, but it can, in many cases contain over 90%, making it very different from the straws of other cereals and even rice straw ash. As identified earlier, this is a valuable raw material suited to many industrial purposes.
- Potassium and calcium contents in rice husk ashes are low compared to rice straw, containing up to 15% K_2O and 3.5% CaO.

Other factors

Due to the exceptional ash composition detailed above, the ash melting temperatures of rice husk are very high, about 1500 °C, which means that rice husk is relatively unproblematic in terms of fouling, sintering and slagging. Furthermore, chlorine content in rice husk is relatively low, commonly below 0.1 w-%. In rice straws, the chlorine content can be as high as 0.7 w-%. This means rice husk has a relatively low corrosion value compared to rice straws.

Physical challenges

The main challenge with rice husk is less about its chemical composition and more about its physical composition. The hard SiO_2 -based structure of rice husk remains during the ashing process, and has a

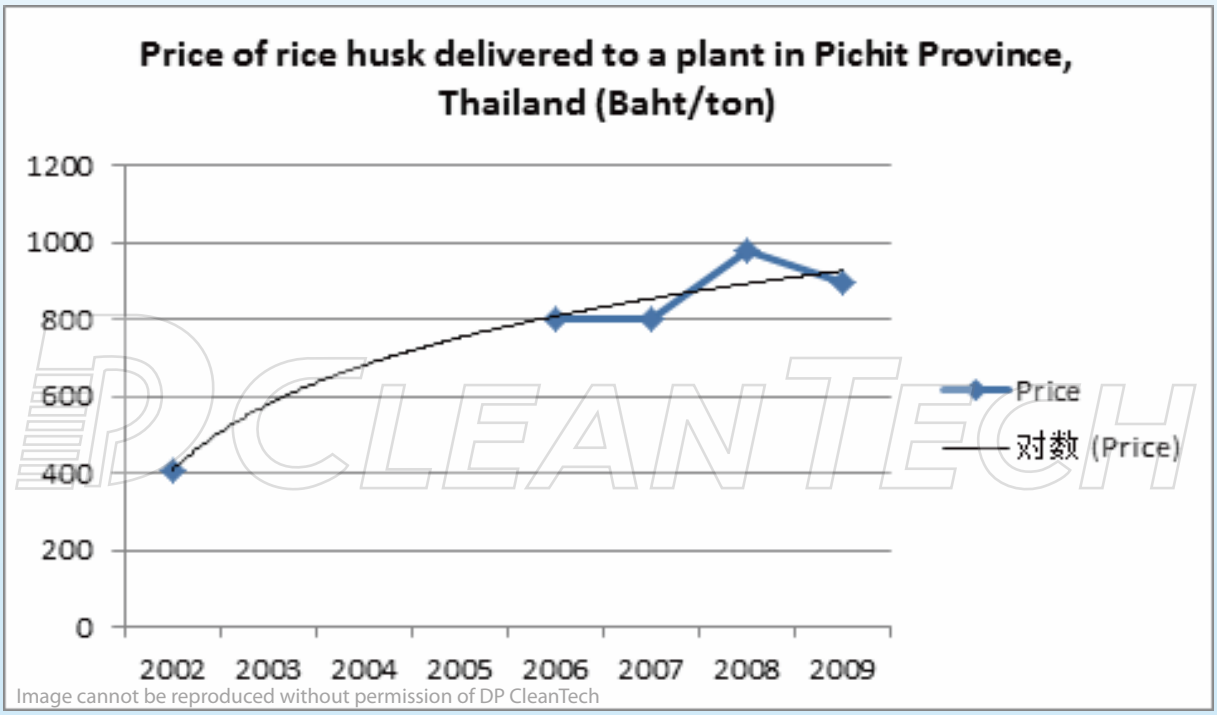
slightly erosive effect due to its large particle size and sharp edges. This creates a "sand blast" effect in the boiler. To combat this, DP uses special materials around the boiler walls and superheaters in order to resist this erosive force and maintain the performance of the plant over long time periods. DP also uses special techniques to reduce the fly ash amount and reduce the flue gas velocity to below 10m/s, this diminishes the erosive impact, while still maintaining high efficiency.

Benefits of using DP CleanTech High Pressure High Temperature technology

High Pressure High Temperature (HPHT) technology yields higher steam parameters and therefore greater efficiency than conventional Medium Pressure Medium Temperature (MPMT) systems. This means a HTHP plant will require less fuel to achieve the same level of electrical and thermal output, which therefore saves on fuel cost.

The following example demonstrates the benefits of using HTHP technology when combusting rice husk biomass. The example takes into consideration the price of rice husk; the physical properties and the performance data using HTHP.

In many countries in Asia where the biomass industry is still fairly under-developed, rice husk prices tend to start off very low (less than US$20 per ton) and rise incrementally as the market becomes better established and demand increases. Prices will then tend to stabilize at around US$40 or US$50 per ton as this is the point at which profitability in biomass reaches its inflexion point.



Source: Asian Institute of Technology 2011

The graph above shows the price of rice husk delivered to a plant in Pichit Province, Thailand. It can be seen that the price started to stabilize from 2008, at around 900 Baht (US$30) per ton.

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Below is a typical fuel analysis for rice husk, which changes little in different regions.

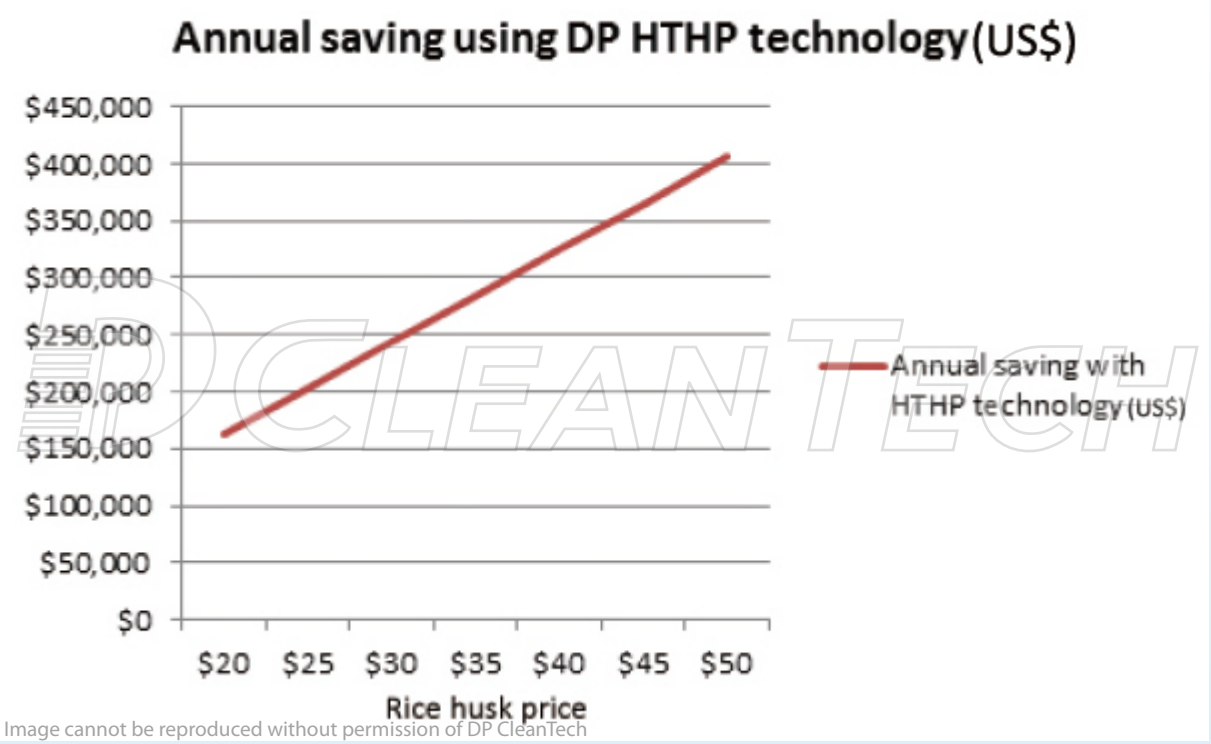
ITEM	UNIT	DESIGN
Carbon	%	34.773
Hydrogen	%	4.530
Oxygen	%	30.436
Nitrogen	%	0.386
Sulphur	%	0.068
Ash	%	14.807
Moisture	%	15.000
LHV	kJ/kg	12655

Source: Biomass Lab, DP CleanTech

Based on the Rice husk fuel analysis we are able to determine some key performance data for a 40 t/h (10MWe) HPHT design and 40t/h (10MWe) MPMT design. Their parameters are 92bar(g) 540°C and 65bar(g) 485°C, respectively.

ITEM	UNIT	HTHP	MPMT
Main Steam Flow	t/h	40	40
Main Steam Temp.	℃	540	485
Main Steam Pressure	bar	92	65
Feed Water Temp.	℃	220	130
Fuel Consumption (FC)	t/h	9.01	10.05
Qty. of fly ash	t/h	0.56	0.63
Qty. of slag	t/h	0.84	0.94

The increased steam parameters of the HTHP system results in improved boiler efficiency, and therefore requires less fuel to achieve the same level of thermal output. Based on annual consumption (operating at 7800 hours per annum) HPHT technology would result in a fuel consumption saving of around 8112 tons per year. Assuming an average fuel price of USD20/ton, this would result in a saving of USD162,240 per annum. If calculating at a peak fuel price of USD50/ton, this would result in a saving of USD405,600 per annum. See chart below



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There is of course an additional capital cost when installing HPHT systems. However based on the above calculations in a mature rice husk market, the additional cost for a superior HTHP system will pay for itself within 3 years.

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Would you like to learn about the combustion potential for your fuel?




DP CleanTech's 'BiomassLab' is an interactive online biomass fuel database, that helps our customers search, analyze and compare biomass fuels from all over the world. The database generates key information about biomass fuels and indicates their properties under combustion and their effectiveness as a fuel. If you have a potential biomass project, anywhere in the world, understanding the fuel is crucial; 'BiomassLab' is therefore a good place to start. Find 'Biomass Lab' on our website:

http://www.dpcleantech.com/biomasslab/the-biomass-lab