UNIT 14 RICE HUSK

Structure

14.0 OBJECTIVES

After reading this unit, you should able to:

- state various properties of rice husk;
- explain combustion and gasification of rice husk; and
- know the various industrial uses of rice husk and ash.

14.1 INTRODUCTION

The large amounts of unusable husks often prove to be an expensive liability to a rice mill rather than an asset. Since the large scale industrial consumption of husk does not seem immediately promising, the economical use of the husks in the rice mill is appropriate and recommendable. The rice mills require heat energy for drying raw as well as parboiled paddy.

One fifth of paddy by weight consists of husks and makes up the largest milling by-product of rice. The commercial utilization or useful consumption of husks will have a major impact on economics of the rice milling industry owing to the world-wide energy crisis.

The physical characteristics of husk often present problems for its commercial utilization. The husks are fragile and porous and therefore, have low bulk density. No other agricultural residue even approaches the amount of silica found in husks (about 15-18 percent), as a consequence husks are very abrasive in character. They are low in nutritional value and add very little to the soil as fertilizer.

Rice husks have a variety of industrial uses which are described in detail as under. However, the profitable utilization in relation to its overall production is very small in practice.

14.2 STRUCTURE, COMPOSITION AND PROPERTIES

14.2.1 Rice Hull Structure

The rice hull constitutes from 18 to 28 per cent (average 22 percent) of rough rice mass. The hull, harsh woody covering around the kernel consists of tow interlocking halves. The larger of the two halves is the flowering glume or lemma; the smaller one is the palea. The outer tip of lemma may be extended into needle shape bristle known as awn; however in some variety this is either small or vestigial. Outer surface of lemma and palea contain short stiff hairs. The lemma overlaps and interlocks with the palea contain short stiff hairs. At the base of the grain separated from the flowering glumes by a short section of rachilla are two sterile glumes. All these components appear in the commercial hull fraction, but the flowering form the predominant material.

14.2.2 Composition and Properties

In general, on an average100 kg of paddy will generate 20 kg of hulls. Short grain varieties produce slightly more hull than medium or long grain varieties. The composition of rice hull is given in table 14.1.

Rice hull has the lowest content of protein and available carbohydrates and the highest content of crude fibre, crude ash, and silica. These factors make rice hull less digestible nutrients, less than 10%.

The main carbohydrate components of rice hulls are cellulose and lignin. Lignin, which is high in rice hull, gives the plants rigidity and binds the cells together. The water-repellent outer covering of rice hull (cutin), amounts to 2.1 to 6% of the hull.

Table 14.1: Composition of rice hull

Constituent	Percent range
Moisture	9.8-11.0
Crude protein	2.9-3.6
Cellulose (fibre)	41.1-43.0
Nitrogen free extract	24.7-28.0
Ash	15.7-18.2

Rice hull has a less bulk density and true density of about 0.1 – 0.16 g/cm^3 and 0.67 – 0.74 g/cm^3 respectively. Hull can be readily compressed to about 0.4 g/cm^3 and grinding increases bulk density of 0.1-0.2 g/cm^3, since the three dimensional structure of it is preserved during ashing.

Thermal conductivity of rice hull is 0.0359 W/m °C is very less and can be used as excellent insulating material. Angle of repose of rice hull is 35° and for ground hull it is 43-45°.

Rice hull contains 16 to 22% ash, and 90-96% of the ash is composed of silica. Therefore, rice hull ash is considered a slightly impure form of silica. Because of high silica content in rice hull (21-22%), the energy content of rice hull is lower than 11.9-13 MJ/kg at 14% moisture. The higher the ash content of rice hulls, the lower the calorific value.

Highest silica content and structure of rice hull makes it very abrasive in character. Metal surfaces in frequent contact with rice hulls will wear out and eventually puncture.

Rice hulls contain only minor levels of potassium and chlorine, and therefore ash melting temperatures of rice hull are much higher than those of rice straw. Thus, you have fewer problems of "slag" (molten glass) deposits when hull rather then straw is used as a fuel.

Check Your Progress 1

Note: a) Use the spaces given below for your answers.

b) Check your answers with those given at the end of the unit.

1. What are the terms lemma, palea and awn refer to?

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2. Explain nutritive content of rice husk?

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3. Why rice husk is abrasive in nature?

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4. Can rice husk be used as insulating material? Why?

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5. How much is the bulk density of rice husk?

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14.3 HUSK AS FUEL

Rice husk can be used as fuel by combustion in excess air and in a controlled atmosphere, by pyrolysis, by gasification (producer gas) and by other chemical and thermo-chemical and biological process. Rice husk has calorific value of 12.55 MJ/kg in comparison to wood 25.1 MJ/kg, coal 29.29-37.65 MJ/kg, and diesel 41.84 MJ/kg etc. Therefore 1 kg of wood will give energy equivalent to 2 kg of husk and similarly 1 kg of coal is equivalent to 3 kg of husk.

Rice husk is used as fuel for steam generation in boilers for rice mills and parboiling plants. As explained above the conversion of rice husk to heat energy is obtained by different thermo-chemical process. Combustion takes place in furnaces and gasification in gassifiers. In furnaces the heat energy generated is used for steam generation in the boilers, where as gassifiers produce a combustible gas to provide heat or generates a fuel gas which can be used in an internal combustion engine as petroleum substitute. The detail description of the furnaces, boilers attached with the husk fired furnaces and the process of gasification is given in the subsequent sections.

14.4 TYPES OF FURNACES AND COMBUSTORS

14.4.1 Combustion

Conversion of rice husk to heat energy must be done in a reactor known as furnace by the process of combustion. Fuel burned in sufficient amount of oxygen, releases large amount of heat, because of the oxidation of the combustible constituents (*viz.* carbon, hydrogen, etc.). This process is known as combustion. On combustion of the fuel first moisture is given off, then volatile matter is liberated, and finally the ash. All the incombustible mineral matter in the fuel is lumped together to be known as ash. It is mainly consists of oxides of silicon's, iron and aluminum.

To burn a fuel efficiently, four basic conditions must be fulfilled.

1. supply of enough air for complete combustion of fuel
2. secure enough turbulence for through mixing of fuel and air
3. maintain the furnace temperature high enough to initiate the incoming air fuel mixture, and
4. provide enough furnace volume to allow time for combustion to be completed.

The theoretical quantity of air required for complete combustion of fuel can be computed by the following equation if ultimate analysis of fuel is known.

$$\text{Mass of air required per kg of fuel} = 11.5\,C + 34.5\,(H - \frac{O}{8}) + 4.35\,S \qquad (1)$$

Ultimate analysis of solid fuels gives the chemical constituents of the fuel such as carbon (C), hydrogen (H), sulphur (S), nitrogen (N), moisture (M) and ash (A) expressed as fraction fractions of moisture free basis of fuel.

$$C + H + S + N + M + A = 1$$

If the ultimate analysis of paddy husk is $C = 31\%$, $H = 4\%$, $O = 16\%$ and $S = 0.7\%$. Then the mass of air required for complete combustion of husk under ideal condition is determined from the equation (1)

$$= 11.5 \times 0.31 + 34.5 \times (0.04 - \frac{0.16}{8}) + 4.35 \times 0.007 = 4.285 \text{ kg}$$

i.e. for complete combustion of 1 kg of husk 4.3 kg of air is ideally required.

How ever, more supply of theoretical air does not secure complete combustion of the fuel due to improper mixing of air and in case of combustion of solid fuels. The amount of excess air depends on the type of fuel and method of burning. Normally 30 to 50 % excess air is supplied in efficient furnaces but values of 60 to 70 % excess air is also common for low heat value fuels like paddy husk.

14.4.2 Types of Furnaces

There are several types of furnaces with fundamental differences. They include fixed bed flat grate, inclined step grate and movable inclined step grate, fluid bed air suspended gas combustor and cyclone furnace.

1. Fire tube boilers and
2. Water tube boilers

Fire tube boilers are further classified into smoke, fire tube and combustion tube boilers. A smoke or fire tube boiler would be a combustion tube type if the fuel enters the tube section in a partially or totally unburnt condition.

In smoke tube boiler, all combustion is completed within the furnace. There is no ash beyond the furnace curtain wall.

In a fire tube boiler some burning of gases occurs within the tube area but all the fuel is converted to gas before entering the tube. This includes boilers of external furnace.

In combustion tube boilers some or all of vaporization occurs within the tube lengths. There is an over lapping area of the furnace, ash removal system and their effect on the distribution of fuel and ash. The most efficient combination is a matched furnace and boiler where in the boiler tubes and gas flow are matched to the desired performance of the furnace. Figure 14.2 shows the fire tube boiler with husk fired furnace

Table 14.2: Performance of a multi pass fire tube boiler

Evaporation cap acity at 100 °C kg/h	Heating surface m^2	Grate area m^2	Husk consumption kg/h	Empty weights (tonnes)	
				Boiler	Furnace Grates, hoppers
500	19	1	200	6	3
750	39	1.5	300	8	3
1000	55	2	400	10	3
1500	75	3	600	12	3.5
2000	100	4	800	14	3.5
2500	125	5	1000	16	4

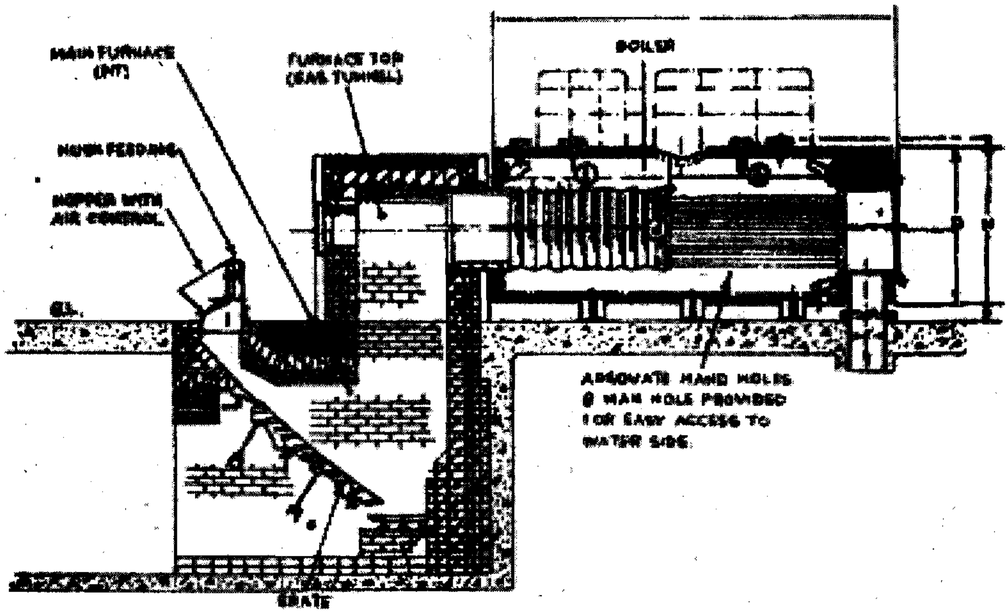
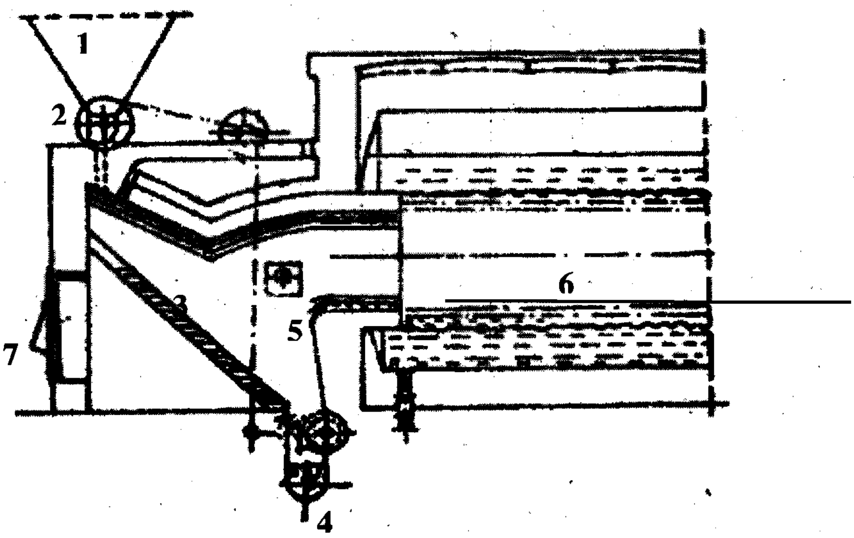


Fig. 14.2: Fire Tube Boiler with Husk Fired Furnace

14.4.3 Inclined Step Grate Furnace

Traditional method of burning husk is an inclined step-grate furnace with a vibratory feeder or any method of ensuring sealing of air and desired metering of husk feed. The diagram of floor level inclined step grate furnace is shown in figure 14.1. The husk is fed into the internal furnace chamber of a boiler pneumatically or manually (1, 2). Transport air for kg of husk is in the range of $3.744 m^3$. For kg of husk for proper combustion $5.928 m^3$ of air is required. The additional air is supplied by induced draft (mechanically by using a fan) or natural draft (by using chimney) (7). To reduce the temperature of the flue gas to the desired level ambient air is allowed to the mixing chamber through port (8). There are several variations in style with emphasis on the special form of the grate bars and proper inclination of the step grate. Very important is the necessary to have a uniform draught through the grate (not more than 1 m/s) and therefore a uniform porosity of the layer of husk and desired products further down the grate.



1. Feeding hopper, 2. Husk conveying roll, 3. Grate, 4. Ash outlet, 5. Baffle, 6. Boiler, 7. Draft inlet for air, 8. Ambient air inlet

Fig. 14.1 : Floor level inclined step grate furnace

14.5 HUSK BASED STEAM BOILERS

A boiler is a device to generate and supply steam at desired temperature and pressure. The boilers are installed in industries to supply process heat and in power stations to generate electricity. In rice processing plants, the boiler performs both these functions i.e. it supplies steam for parboiling of paddy and heat the air in a steam heat exchangers for drying of paddy and also develop mechanical power to operate the rice mills and other processing equipments in the processing complexes.

In rice mills use of paddy husk, a byproduct of the rice mill as fuel for steam generation in boiler is the most common and popular. One of the best examples of beneficial use exists in India, where 60% of the total husk available nationally is used as source of energy for parboiling and drying.

The efficiency of the industrial boiler with husk fired furnace for steam generation ranged in between 50-60%. The major loss is due to the energy carried away by the exhaust flue gases leaving through the chimney. The gases from fuel combustion cannot be cooled to air temperature in the boiler room and therefore all the heat which is released by the combustion of the fuel cannot be reused.

Boilers are broadly classified as :

14.6 GASIFICATION

Gasification is the thermal decomposition of organic material at elevated temperatures in an oxygen restricted environment. The process, which requires an initial heat supply to get underway, produces a mixture of combustible gases (primarily methane, complex hydrocarbons, hydrogen and carbon monoxide). This producer gas can then either be used in boilers or cleaned up and used in combustion turbines or in generators. The gasification process is either self sustaining once the operating temperature is reached or it can be maintained by recycling a small proportion of the energy produced from the combustion of the fuel gases.

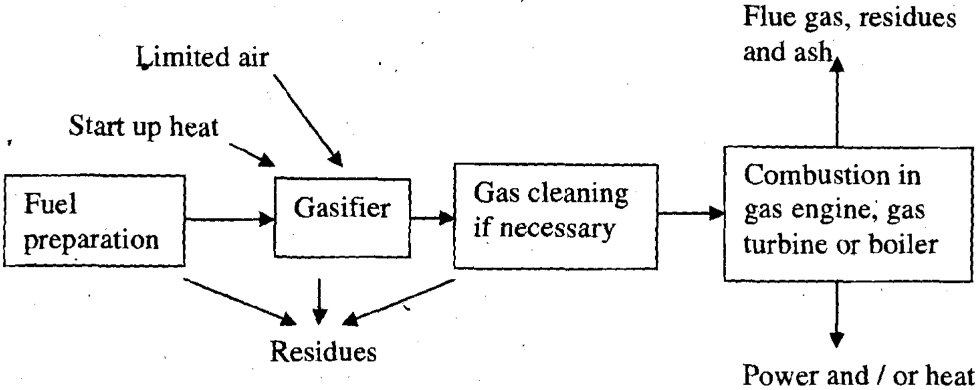


Fig. 14.3: Process flow diagram for Gasification

The process flow diagram for Gasification is shown in Figure: 14.3 (the diagram for pyrolysis being remarkably similar). Thermal pyrolysis is only different from the gasification process in that the thermal decomposition takes place in the absence of oxygen. The only necessary modifications to the gasification process diagram are that there will be no air input into the pyrolyser which will result in the creation of an energy rich oil and combustible solid residue (known as char) together with the fuel gas.

When comparing to mass burn, there are several clear advantages. It can be a more efficient technology. Biomass gasifier has a 36% efficiency compared to 21% for mass burning. The major environmental benefit of these processes are that they retain pollutants (the sulphur, heavy metals etc.) in the ash instead of them being moved to the gas phase and discharged to the atmosphere. Therefore the emissions form this technology are much lower than produced by conventional incineration and will require less flue gas treatment. In fact, there is often no need for a smoke stack as the emissions only come from the burning combustible gases in a turbine or boiler.

One disadvantage with the process is the necessary fuel preparation. The fuel material is required to be shredded before being fed to the gasifier, which entails cost. However, with the savings made by not requiring the level of emission controls, the process can prove economically profitable. The major drawback to these systems is with getting past the planning stage. Advanced thermal technologies like these are still categorised as incineration when it comes to planning. The public generally have misconceptions as to the word "Incineration" as most expect huge visual intrusion and dangerous smoky emissions. This is the reason why the granting of planning permission is often resisted by the local community. The absence of a smokestack, however should help with planning permission applications.

Types of Gasifiers

Fixed Bed Gasifiers

Updraft Gasifier (UDG): Biomass enters through a lock-hopper and flows down against the flow of blast and generated gas. The counter flow arrangement is more tolerant to biomass moisture (up to 40 or 50%M) because drying occurs with produced gas, but the gas is loaded with tar (>5% to 10% tar), so it is usually only useful for staged combustion. The dirty product gas of the UDG means that it is not applicable for most applications that require clean gas, such as synthetic fuel, chemical or gas turbine applications. These are best for heat only applications, such as boiler firing.

Downdraft Gasifier (DDG): Biomass enters through an open top in an air-blown system or through a lock-hopper in an oxygen-blown system. The open top DDG design is simple and low-cost. Gas suction is required for operation, which is why it works well with internal combustion engines for small-scale power generation. The counter flow arrangement gives discrete zones of pyrolysis (flame front) and char gasification. Biomass and main pyrolysis air enter through the top with generated gas and char exiting the reactor at the bottom. Adding blast to the char zone is an excellent approach for achieving low tar gas (<100 mg tar/Nm^3). In effect, this is a two-stage gasifier with a plug flow reactor configuration, which is why tar production is often very low. The downdraft gasifier is useful for small scale applications, and may have a practical upper limit of 1 to 1.5 MW (or 40 to 48 inch diameter.)

Fluidized Bed Gasifiers

Bubbling Fluidized Bed (BFB): The BFB gasifier is well known and commonly used because of its reliable performance, isothermal operation, and suitability to large scale application. The fluidized bed gives rapid heating of reactant gases in addition to excellent mixing of biomass solids and inert media. The inert fluidizing media is typically comprised of silica, mullite, or olivine sand, and contributes substantial thermal ballast during startup and operation, which lends to its stable operation. Air, steam or oxygen blends are delivered through a flow distributor (perforated plate/cone or manifold array) into a fluidized bed of sand. Biomass is delivered into the bubbling bed via an auger from an air-locked hopper. Tar production is moderately high at 1% to 2%, but less than a fixed bed updraft gasifier. The fluid bed has less than ideal tar production because of internal gas bypassing via the bubbles in the bed and because devolatilization may be occuring uniformly through the emulsion of gas and solid particles (much like an idealized well mixed reactor), therefore tar slip does occur. In any case, the BFB is quite robust for both pyrolysis and gasification, but secondary processing of the generated gas may be required for more critical applications besides strictly thermal energy supply.

Circulating Fluidized Bed (CFB): The CFB gasifier has no distinct interface between the dense phase of fluidized sand and the freeboard (dilute particle phase). In fact the higher velocity fluidization regime means that there is a particle density gradient from the bottom of the gasifier to the top. Entrained media and char fines are recycled back to the gasifier via a retention cyclone. The higher velocity regime gives an alternative approach to increasing char residence time to promote higher efficiency gasification. However, detailed studies show similar carbon conversion limits in a CFB Gasifier (92%) compared to a BFB Gasifier. Alternative design approaches are being considered at various research institutions, however, to improve carbon conversion through staged oxidation within the reaction column.

Entrained Flow

Entrained flow gasifiers are commonly used for coal because finer particle sizes and higher operating temperatures can be achieved to achieve complete conversion. However, entrained flow gasifiers are not practical for biomass for several reasons including operating temperature limiting properties of biomass ash and the impracticality of generating finely ground biomass feedstock. Biomass also has a high porosity (lower energy density) and higher moisture holding capacity, which makes it impractical to slurry feed biomass—a common approach for solids feeding to high pressure for most commercial coal gasifiers.

Check Your Progress 2

Note: a) Use the spaces given below for your answers.

b) Check your answers with those given at the end of the unit.

1. Give the calorific value of rice husk, coal, wood and diesel?

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2. Define combustion?

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3. What are the conditions to burn a fuel efficiently?

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4. State different type of furnaces?

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5. In rice processing plants, what are the two functions that a boiler can perform?

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6. What is gasification?

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7. Draw the flow diagram of gasification process?

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8. What is the difference between gasification and pyrolysis?

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9. What are advantages and disadvantages of gasifiers?

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14.7 NATURE OF ASH AND IT USES

14.7.1 Rice Husk Ash

When rice husk is burnt for energy production or disposal, resulting as is an important by product for many industrial applications

Composition:

SiO_2	: 95.00%
CaO	: 0.70%
MgO	:0.015%
Fe_2O_3	:0.09%
Al_2O_3	:0.00%
MnO_2	:0.05%

Main constituent of ash is silica. Depending on type of combustion process ash varies from high carbon char to a carbon free white ash. If temperature of combustion is very high (1000 to 1200 °C) mostly black ash is produced and if husk is burnt slowly at low temperature carbon free white ash is produced.

14.7.2 Uses of Both Types of Husk Ash are Given Below

1) Oil absorbent: Micro porous structure of silica in ash causes absorption of oil by it. Ash is used as grease-sweep for removing oil stains and for cleaning floors in petrol pumps, kitchens, oil refineries etc.

2) Washing powder: White ash mixed with 10 to 25% washing soda and ground to powder produces a product similar to "Vim Powder" popular domestic cleaning powder. This application has good potential in India.

3) Water purification: Black ash or husk char is used as filter medium for purification of water

4) Filler material in rubber compounding: White ash is used as reinforcing agent in compounding of rubber in place of carbon black

5) Rice husk cement: White carbon free husk ash mixed with slaked lime Ca $(OH)_2$ and Portland cement. Husk cement may be used in plastering, lining of canal walls forpreventing seepage, making building blocks and as cement mortar for lying of bricks.

6) Sodium silicate: Sodium silicate is produced by chemical reaction of white ash with caustic soda as shown in following reaction.

$$SiO_2 + 2NaOH = Na_2SiO_3 + H_2O$$

Sodium silicate is a base material for many chemical products such as precipitated silica, silane, silicon tetra chloride and finally solar grade silicon, Sodium Silicate has good binding properties and is used in manufacture of straw board

Check Your Progress 3

Note: a) Use the spaces given below for your answers.

b) Check your answers with those given at the end of the unit.

1. Give the composition of rice husk ash?

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2. Explain white and black ash?

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3. How the rice husk ash is useful?

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14.8 OTHER SPECIFIED USES OF RICE HUSK

Some other uses of rice husk are given below

1. Use of rice husk as admixture in animal feed

The average composition and digestible nutrients of rice husk is given in Table 14.3.

Table 14.3 : Digestible nutrients of rice husk

Constituents	Percentage
Total dry matter	92.0
Digestible protein	0.1
Total digestible nutrients	9.9
Average total composition	
Protein	3.0
Fat	0.8
Fibre	40.7
N- free extract	28.4
Mineral matter	19.1

Though rice husk has a low nutritive value, in many countries they have been used an admixture in cattle feed. In ordered to soften the husk to increase the digestible protein, husk is ammoniated with anhydrous ammonia at raised temperature and pressure in the presence of monocalcium phosphate. The use of husk is considered inadvisable in Italy. The husk is prohibited in Spain.

2. Use of Rice husk as a Mulch soil conditioner

In many countries a large amount of husk are returned to the land for purpose of soil conditioning. Rice husk used mulch for growing cotton (Australia), rice (Japan), onions (Philippine), and vegetable and flowers (Thailand). In the Sacramento Valley of California, most of the husk is deposed off by ploughing directly into the soil. Rice husk is also used as an admixture in some fertilizers, even though it adds very little N, P or K value to the product.

As a mulch, rice husk retains water and tend to keep the soil moist. As an admix, rice husk helps preventing the caking of fertilizer and also tends to make the soil condition higher. The agriculture extension service of University of California, Davis, carried out a study of 100 tonnes of ground husk per acre of heavy soil resulted in a highly significant depression in the rice yield. The study neither proved nor ruled out the possibility of nitrogen immobilization or chlorine-nitrogen interaction due to the husk decomposition.

3 Use of husk for the production of Furfural

Commercial furfural is a pale yellow liquid with the odour of almonds and is obtained from agricultural residues namely, corns, cotton seed husks and rice husks. Furfural is extensively used as selective solvent in purifying lubricating oil, diesel oil, wood resin, and vegetable oils. Furfural is also used as a selective solvent in the extrication, distillation for the separation and purification of carbon, hydrocarbons in connection with butadiene production. Recently furfural found other uses as a plasticizer for automobile manufactured parts, disinfectants, fungicides and bactericides. Furfural when thickened with starch becomes a satisfactory paint and varnish removal. The latest, and possibly the largest use, of furfural is a chemical, intermediate products such as furon, tetrahydrofurfural, alcohol, methyletetrahydrofuron, etc.

4. Use of rice husk to produce cellulose and pulp

Rice husks were investigated as a possible raw material for making paper. The alpha-cellulose content of husk is comparatively very low and fibre is very short. The northern regional laboratory of USDA evaluated the cellulose pulp made from husk and concluded that the fibres are too short to contribute any strength properties to paper. Rice husk also have a low bulk density and require a large amount of chemical for reduction to fibre. The mechanical processing is non competitive with that for wood pulp.

5. Use of rice husk as admixture in building materials

In an effort to explore new uses of husk it was investigated the possibility of using husk in building materials. Density of fifteen different mixtures of husk, rice husk concrete ranged from 1095 kg/m^3 to 1745 kg/m^3 as compared with 2380 kg/m^3 for sand gravel cement concrete. In general, when the volume of total aggregate to cement is constant, the compressive strength is affected by the ratio of rice husk ash to rice husk. The investigator concluded that the concrete made did not have adequate strength and stability at a competitive cost with the sand-gravel- cement concrete, though it had higher insulating value than ordinary concrete.

The use of husk as an aggregate in light weight concrete blocks or bricks has also been tried at Tropical Products Institute of United Kingdom. The blocks were made of a mixture of husk, cement and water, and were reported to have survived a cold winter with no deterioration. The institute is of the opinion that the husk can be successfully used as an admixture in light weight concrete blocks if care is exercised in the preparation of the mix and if pressure moulding is practiced.

6. Use of rice husk as insulating material

Rice husk have been used as loose insulating material in buildings, farm structures and cold storage plants in many countries. The loose fill of husk between interior and exterior walls represent a fire hazard unless treated with borax and boric acid for flame proofing.

Husk, as with other loose fill materials must be sealed with effective vapour barrier to prevent condensation of moisture with the material under various ambient and environmental conditions.

Rice husk have also been used effectively as packaging material for the protection of eggs, fruits, china- ware and other fragile commodities from damage during handling and transportation. The advent of foam plastics and the availability of wood wool and shavings have, however, limited the use of husk for packaging materials.

7. Use of rice husk in hard panel board

Recently the use of husk in panel and composite boards based on modern day technology has proved economically advantageous. The physical characteristics of panel board vary from the very hard, high density particle boards to the soft pulp like panels becoming upon their intended use. Some panel boards are intended for exterior use, some for interior use only; some as wall boards, floors or ceilings. It is technically feasible for husk for manufacturing of many of these boards and the cheaper methods are being developed.

8. Use of rice husk as filler

Many investigators have given consideration to the use of ground husk as filler for phenolic resin wood adhesives, plastics and animal glues. The rice husk was decomposed by means of alkalities for preparing gel. The residue after alkali decomposition consisted mainly of cellulose, proteins and pentosons. The extract was acidified to form a gel which was claimed to be excellent filler for phenolic resin and animal glues.

9. Dry distillation of rice husk to produce chemical and charcoal

The charcoal and chemicals like acetic acid, methanol and tar can be produced from husk by dry distillation. When agricultural wastes or wood is heated in absence of air to about 315 °C spontaneous decomposition with a generation of heat takes place. The residue is charcoal and the vapours on condensation results in a gas of low calorific value and the water solution. This water solution on distillation can be separated into methanol, acetic acid and tar. The product obtained by destructive distillation of rice husk is shown in table 14.4

Table 14.4: Products obtained by destructive distillation of rice husk

Product	Percent by weight	
	Min	Max
Liquor	40.9	43.2
Charcoal	37.1	39.8
Acetic acid	2.99	3.58
Methonal	1.30	2.07
Acetone	0.41	0.81
Loss (by difference)	17.30	10.5

The charcoal thus formed, was finely divided and difficult to remove from the process. The methanol and acetone are produced in synthetic plants at a lower cost. This rendered the use of rice hulls uneconomical. Despite the early investigation on the preparation of charcoal and active carbon from rice husk, there has not been large scale consumption of rice husk for these products.

Check Your Progress 4

Note: a) Use the spaces given below for your answers.

b) Check your answers with those given at the end of the unit.

1. What are the uses of rice husk?

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14.9 LET US SUM UP

The large amounts of unusable husks often prove to be an expensive liability to a rice mill rather than an asset. Disposal of this low value by product poses a serious problem because of its abrasive characteristics, low nutritive value, low bulk density, and high ash content. Since the large scale industrial consumption of husk does not seem immediately promising, the economical use of the husks in the rice mill is appropriate and recommendable.

Rice husk can be used as fuel by combustion in excess air and in a controlled atmosphere, by pyrolysis, by gasification (producer gas) and by other chemical and thermo-chemical and biological process. Rice husk has calorific value of 12.55 MJ/kg in comparison to wood 25.1 MJ/kg, coal 29.29-37.65 MJ/kg, and diesel 41.84 MJ/kg etc. Therefore 1 kg of wood will give energy equivalent to 2 kg of husk and similarly 1 kg of coal is equivalent to 3 kg of husk.

Rice husk can also be used as admixture in animal feed, as a mulch soil conditioner, for the production of Furfural, to produce cellulose and pulp, as admixture in building materials, as insulating material, in hard panel board, as filler material and to produce chemical and charcoal etc.

14.10 KEY WORDS

Combustion : Process of release of heat by exothermic heat of reaction by oxidation of combustible constituents in the fuel

Gasification : is the thermal decomposition of organic material at elevated temperatures in an oxygen restricted environment

Boiler : is a device to generate and supply steam at desired temperature and pressure

Pyrolysis : is thermal decomposition of organic material at elevated temperatures in the absence of oxygen.

14.11 SOME USEFUL REFERENCES

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3. Champagne, E. T., Ed. Rice: Chemistry and Technology, 2nd ed. Am. Assoc. Cereal Chem., St. Paul, MN.

14.12 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress Exercise 1

1. The hull, harsh woody covering around the kernel consists of two interlocking halves.

   The larger of the two halves is the flowering glume or lemma; the smaller one is the palea.

   The outer tip of lemma may be extended into needle shape bristle known as awn

2. Rice hull has the lowest content of protein and available carbohydrates and the highest content of crude fibre, crude ash, and silica.

   These factors make rice hull less digestible nutrients, less than 10%.

3. Highest silica content and structure of rice hull makes it very abrasive in character

4. Yes, because thermal conductivity of rice hull is very less (0.0359 W/m °C)

5. 0.1– 0.16 g/cm^3

Check Your Progress 2

1. Rice husk - 12.55 MJ/kg, wood 25.1 MJ/kg, coal 29.29-37.65 MJ/kg, and diesel 41.84 MJ/kg etc

2. Process of release of heat by exothermic heat of reaction by oxidation of combustible constituents in the fuel

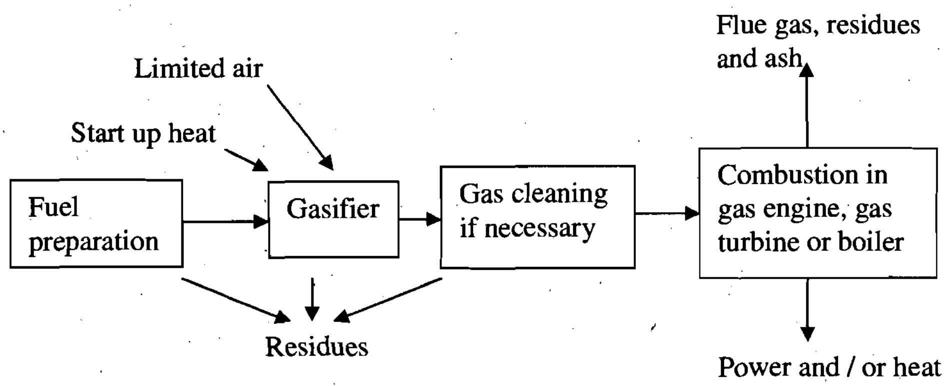
3.
   - supply of enough air for complete combustion of fuel,
   - secure enough turbulence for through mixing of fuel and air,
   - maintain the furnace temperature high enough to initiate the incoming air fuel mixture,
   - provide enough furnace volume to allow time for combustion to be completed.

4. fixed bed flat grate, inclined step grate and movable inclined step grate, fluid bed air suspended gas combustor and cyclone furnace.

5.
   - supplies steam for parboiling of paddy and heat the air in a steam heat exchangers for drying of paddy,
   - develop mechanical power to operate the rice mills and other processing equipments in the processing complexes.

6. Thermal decomposition of organic material at elevated temperatures in an oxygen restricted environment.

7.



8. Pyrolysis is only different from the gasification process in that the thermal decomposition takes place in the absence of oxygen.

9. Advantage :

   retain pollutants (the sulphur, heavy metals etc.) in the ash instead of them being moved to the gas phase and discharged to the atmosphere.

   Disadvantage :

   fuel preparation necessary

Check Your Progress 3

1. SiO_2 - 95.00%, CaO - 0.70%, MgO - 0.015%, Fe_2O_3 - 0.09%, Al_2O_3 - 0.00%, MnO_2 - 0.05%

2. If temperature of combustion is very high (1000 to 1200 °C) mostly black ash (high carbon char) is produced and if husk is burnt slowly at low temperature carbon free white ash is produced

3. Oil absorbent, Washing powder, Water purification, Filler material in rubber compounding, Rice husk cement, Sodium silicate

Check Your Progress 4

1. As boiler fuel, as admixture in animal feed, as a mulch soil conditioner, for the production of Furfural, to produce cellulose and pulp, as admixture in building materials, as insulating material, in hard panel board, as filler material and to produce chemical and charcoal etc.