WASTE HEAT RECOVERY IN THE CARBONISATION OF COCONUT SHELL IN SRI LANKA

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INTRODUCTION

Coconut industry plays a vital role in the economy of Sri Lanka. The total land area under coconut cultivation is 1.1 million acres. This extent of land is second only to paddy cultivation. The coconut industry provides employment to over 100,000 people. Its contribution to our G. D. P. is 5%. The annual foreign exchange earnings amount to over Rs. 2000 million, which is about 8% of the total foreign exchange earnings.

COCONUT SHELL—AN IMPORTANT BY PRODUCT

Coconut shell is an inportant by product in the coconut industry. The total annual production of coconuts in Sri Lanka is about 2,500 million. Hence we get this quantity of shells as a by product of this industry. About 56% of the shells are used as fuel for cooking in the domestic sector. 12% of the shells are used as fuel for copra curing and the balance 32% of the shells are converted into charcoal for export.

COCONUT SHELL CHARCOAL FOR EXPORT

The average price of coconut shell charcoal is about Rs. 4,700 per tonne. Furnace oil with a calorific value of 40,000 kJ/kg. is sold at an average price of Rs. 5,000 per tonne in Sri Lanka. Since coconut shell charcoal has a calorific value of 30,000 kJ/kg. the equivalent price should be only Rs. 3,750 per tonne. Moreover, coconut shell charcoal being a solid fuel has a lower combustion efficiency and a higher handling costs. Hence it is beneficial to export coconut shell charcoal at Rs. 4,700 per tonne than using it as a fuel locally.

TRADITIONAL METHOD

Coconut shells are usually converted into charcoal by the traditional "pit method" by partially burning the shells in brick-lined pits.

In this method, all volatile components present in the shells are vented into the atmosphere in the form of smoke. Nearly 65% of the heat content in the original shells are wasted in this manner. Moreover, the smoke generated in this process is considered by local inhabitants as obnoxious and as a result public resistance is building against this process. Another draw back in this process is the 10-15% rejection of charcoal due to contamination by foreign matter and over carbonisation of shells.

THE WASTE HEAT RECOVERY UNIT

The Tropical Development and Research Institute (TDRI) of the United Kingdom has developed a technology in which while good quality charcoal is manufactured in a metalic kiln, the combustible volatile components evolved during carbonisation are captured and combusted in a special chamber to produce process heat. The TDRI has named this unit the Waste Heat Recovery Unit (WHRU).

FIRST "WHRU" IN SRI LANKA

At the request of the Coconut Development Authority (CDA), the TDRI is introducing this technology to the coconut industry in Sri Lanka. A WHRU fabricated in the United Kingdom has been installed at the Marandagahamulla Desiccated Coconut Mills near Minuwangoda with the assistance of TDRI officials. A sketch of the WHRU is shown.

DETAILS OF WHRU

The cylindrical metal kiln (1) for carbonising the shells is made of 10 mm thick mild steel plate and has a capacity of about 8 m^3. Two hatches (2) and (3) are provided for loading the coconut shells from the top of the kiln at the beginning of the process and for unloading the charcoal near the base of the kiln at the end of the process. Removable mild steel rods (4) are provided at the bottom of the kiln to support the charcoal and to permit the passage of gases from the kiln through the gas outlet pipe (5). Six ports are provided at equidistant around the circumference of the kiln for lighting the charge. A right-angled bend (7) with a damper (8) to control the flow of air into the kiln and a metal mesh cage (9) is hinged on to each of these ports so that this assembly can be swung into position soon after lighting the charge. The purpose of the mesh cage is to trap any flame or hot char during a "blow back".

The combustible gases produced during carbonisation known as kiln gas is drawn through the gas outlet pipes (5) and (10). The damper (11) is provided to control the flow of kiln gas to the combustion chamber. Liquids condensed during the operation are collected through a value (12) at periodic intervals. A copper mesh (13) acts as a flame trap. Air provided by the primary air fan (14) is mixed with the kiln gas just before entry to combustion chamber (16). The primary air fan is powered by a 1.5 kW motor. A valve (15) is provided to control the flow of primary air. A thimble

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(17) made of a cast iron tube with holes is filled with burning charcoal is inserted into the combustion chamber. The kiln gas when it enters the combustion chamber gets ignited by the burning charcoal. Secondary air required for combustion is provided through slots made on the front side of the combustion chamber. These slots are provided with sliding plates to adjust the flow of secondary air.

The products of combustion are drawn into the furnace (18). This is a standard furnace used in the manufacture of desiccated coconut and is usually fired with fuel wood. The WHRU replaces the heat energy usually provided by the fuelwood. The draught required for drawing air into the kiln and to draw the kiln gas from the kiln through the furnace is provided by an induced draught fan (19) powered by a 5 kW electric motor.

OPERATION OF THE WHRU

The 8 m^3 capacity kiln holds about 1.5 tonnes of sun dried coconut shells. 7,500 pairs of shells are required to make up this quantity. Before loading the kiln with shells, wooden poles of about 1.5 meters in length and about 600 mm in diameter are inserted into the six ports. The outlet hatch is tightly closed. The kiln is then loaded with sun dried (10% moisture content) shells. The loading hatch is tightly closed. The wooden poles inserted through the ports are gently withdrawn, thus creating a cavity. A charge of burning charcoal is introduced into these cavities. The induced draught fan and the primary air fan are switched on. The right-angled bends at the six ports are swung into position and well tightened. The evolution of kiln gas starts gently and gradually increases and in a few minutes gets ignited in the combustion chamber. The sliding plates of the slots on the combustion chamber are adjusted to get a smoke-free and clear flue gas through the chimney.

The thermal output of the combustion chamber is rated at 600,000 kJ/hour. The kiln once loaded with 1.5 tonnes of shells, will produce kiln gas for 10 hours of operation. The temperature of the kiln gas before combustion is about 100°c. The temperature of the flue gas at the outlet of the I. D. fan is about 250°c. An air heater attached to the furnace supplies clean, hot air at 100°c to a desiccated coconut dryer. During a 10-hour operation of the kiln, 1400 kg of desiccated coconut can be produced. Normally about 1000 kg. of fuelwood is required provide heat to manufacture this quantity of desiccated coconut using a conventional wood-fired furnace.

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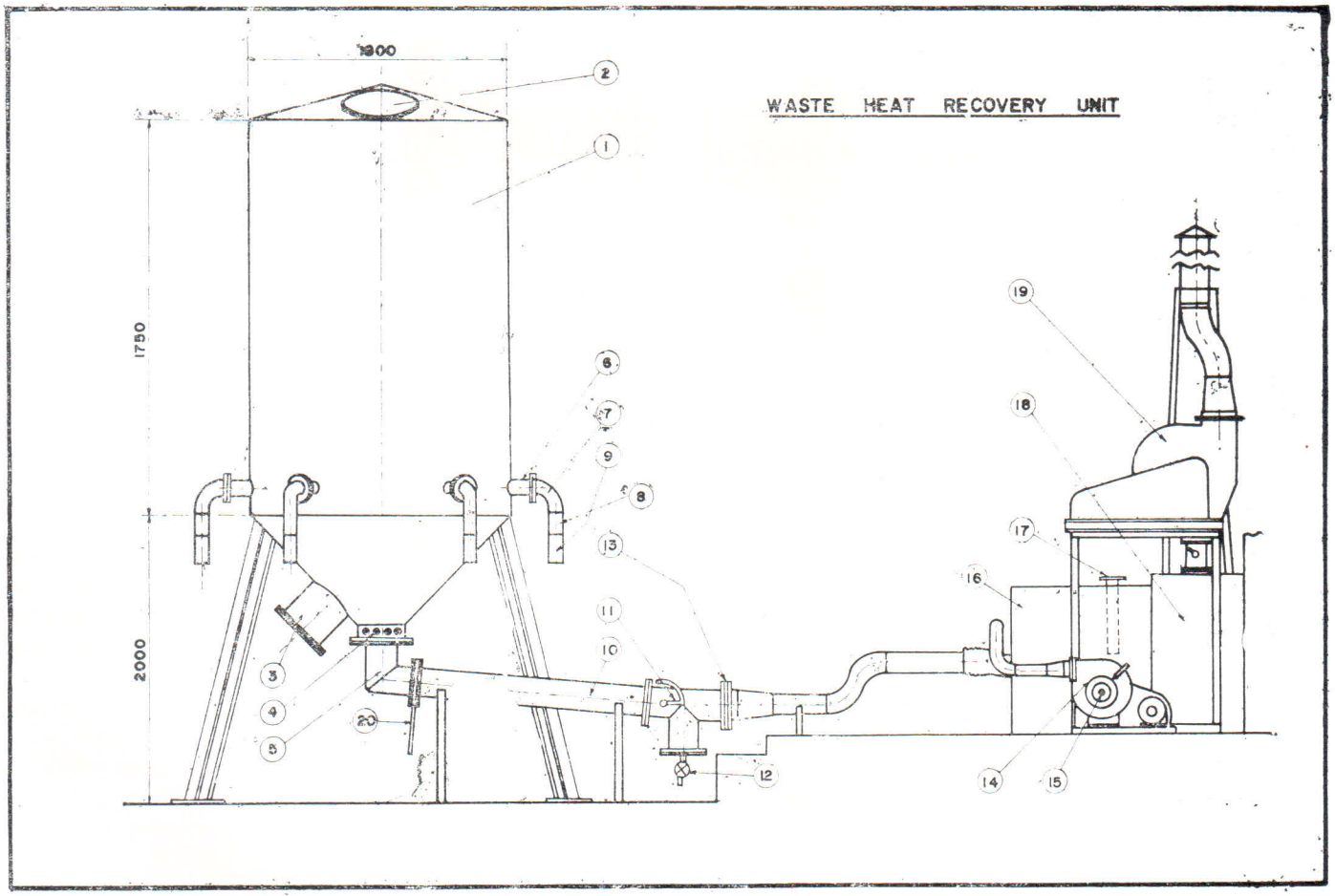

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SHUT DOWN

After about 10 hours of operation, the carbonisation of the 1.5 tonnes of shells will be completed. As this status is approaching, the temperature of kiln gas at the kiln outlet will increase from 100°c to 200°c. At this stage, the kiln is shut down. The dampers at the six ports of the kiln are closed and blanking plates are inserted and tightened to prevent any ingress of air into the kiln. Another blanking plate (20) is inserted at the gas outlet pipe and well tightened.

From this time onwards, the temperature inside the kiln keeps dropping. After about 12 hours from shut down, the kiln will be ready for unloading. The outlet hatch (3) is opened and the charcoal is carefully loaded in 45 gallon steel drums. These drums are tightly closed and kept for about 12 hours to prevent re-ignition by atmospheric oxygen.

THE SECOND UNIT

A second WHR unit is being fabricated Sri Lanka and will be installed very soon at a mill close to the Marandagahamulla Mills. The fabrication, installation and operation of this unit will give the necessary information to propogate this technology to the entire coconut industry.

ECONOMIC EVALUATION

WHRU METHOD

Expenditure	*Rs.*
Total cost of WHRU: Rs. 150,000	
Annual capital repayment and interest (20%)	30,000
Annual maintenance (10%)	15,000
Cost of Shells (Rs. 200/1000 Shells × 7,500 Shells per day × 200 days per year)	300,000
Cost of Electricity (3 kW, 4KVA, 10 hrs. per day, Rs. 1.45/kWh, Rs. 100/kVA)	13,500
Labour (4men × Rs. 500 per month × 12 months per year)	24,000
EPF (17%)	4,080
Total:	386,580
Income	
Value of Kiln Gas (equivalent to 1000 kg. of wood at Rs. 600 per tonne for 200 days)	120,000
Value of Charcoal (0.5 tonnes per day, Rs. 4,700 per tonne, 200 days)	470,000
Total:	590,000
Profit	203,420

TRADITIONAL METHOD

In the traditional method, the yield of charcoa is 25% of the weight of fresh shells burnt instead of th 30% yield from the WHRU method. Hence the yiel from 7500 shells by the traditional method will be onl 0.42 tonnes instead of the 0.5 tomnes obtained fro the WHRU method. In the traditional method, th carbonisation is carried out usually on a contrac basis. A contractor is paid Rs. 115/- to produc 1 tonne of charcoal.

Expenditure	*Rs.*
Cost of shells (Rs. 200/1000 shells × 7500 shells per day × 200 days per year)	300,00
Carbonisation cost (Rs. 115 per tonne × 0.42 tonne per day × 200 days)	9,66
Total:	309,66

(Capital expenditure incurred in constructing th pit kiln is neglected).

Income	*Rs.*
Value of Charcoal (0.42 tonnes per day × Rs. 4700 per tonne × 200 days)	394,80
Profit	85,14

NET PROFIT

Thus the WHRU method gives an annual prof of Rs. 118,280/- **MORE** than the profit obtained i the traditional method.

OTHER BENEFITS

The yield of charcoal from the traditional pi method is about 25% of the weight of shells. In th WHRU the yield is 30%.

In the traditional method, the charcoal get contaminated with foreign matter and some shells ar over-carbonised. This leads to a rejection of abou 10-15% of the Charcoal produced. This rejection i eliminated in the WHRU process.

FUTURE STRATEGIES

INCREASED PRODUCTION

At present about 12% of our coconut productio is utilized for the manufacture of desiccated coconu 28% for copra making and 60% as domestic food nut The Coconut Development Authority (CDA) is plannin to extend the WARU technology to the entire desiccate coconut and copra industry in Sri Lanka. When thi task is achieved, all the shells produced in the desiccate coconut and copra industries will be converted int charcoal while all the thermal energy required for thes the industries will be provided by the WHRUS. Thi will increase the coconut shell charcoal production fro the present 32% to 40% of the total shells produce annually.

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