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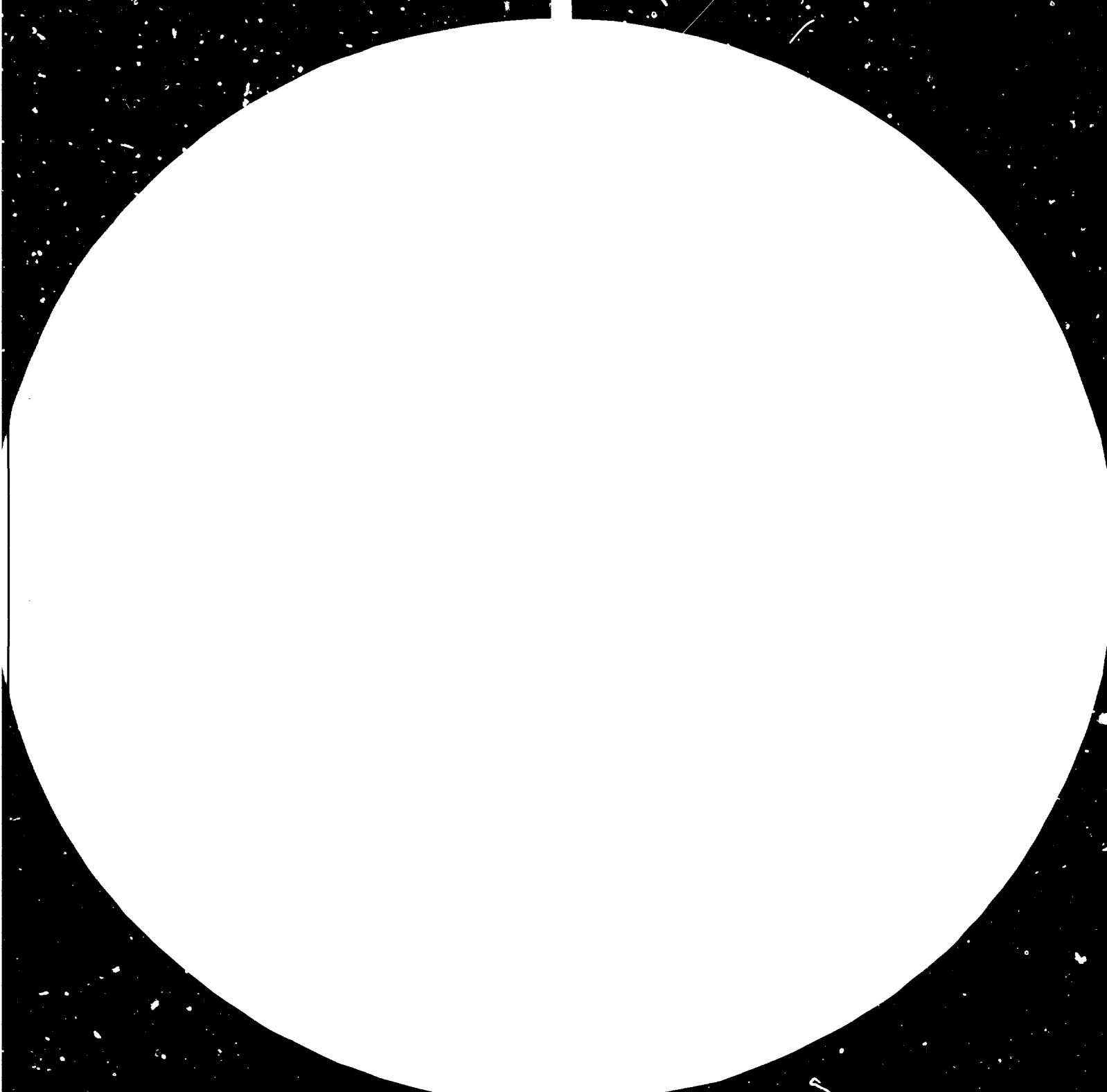

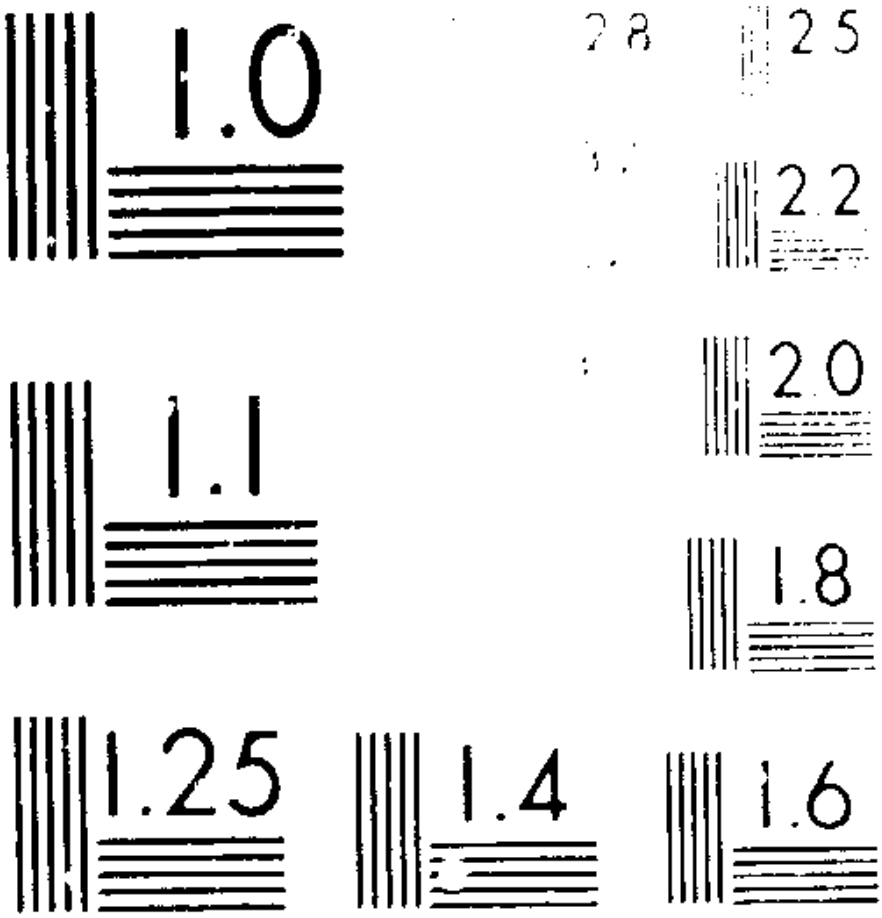
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EQUIPMENT FOR POWER GENERATION BASED ON WOOD WASTES APPROPRIATE FOR WOOD PROCESSING INDUSTRIES IN DEVELOPING COUNTRIES *

by

Walter O. Zerbin **

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1. Introduction

Wood or wood waste at the spot of energy requirements is an ideal primary energy source for power and heat generation. If in addition transport is difficult, one can hardly do without these natural renewable energy sources.

There are basically two different ways of using wood as an energy source: a) either it is burned in a furnace or stove, using the heat for steam generation and subsequent conversion to electricity and so on or b) the wood is gasified in a gasifer, producing the so-called gen-gas which will be converted to electric power or burned to produce heat for process or heating purposes.

Producing energy by means of steam generation in small units is relatively inefficient and expensive. Using gen-gas mechanic power generated by a gas engine is far cheaper in both investment and in operation. Gen-gas is efficient for any size load and automatic operation (for example, at night) can easily be incorporated. Also with this method, waste heat is generated on a higher temperature level appropriate for a wider range of applications.

These advantages, together with many others, have lead to an ever-growing importance of the gen-gas power stations, especially in developing countries and even in the industrialized nations.

2. Concepts and Constructions of Gen-Gas Plants

The center of a gen-gas power station is the gasifier converting wood and wood wastes to a combustible gas consisting of the following components:

Carbon monoxide	CO	20 to 25%	average 23%
Hydrogen	H2	10 to 25%	average 15%
Methane	CH4	0 to 4%	average 2%
Carbon dioxide	CO2	2 to 15%	average 10%
Nitrogen	N2	45 to 60%	average 50%
Net calorific value	kJ/Nm^3	4200 to 5700	average 4800

The following approximate values can be given:

1 kilo of wood gives an average of 2.2 Nm^3 gen-gas;
1.2 kilos of wood gives an average of 1 kWh electricity;
3.5 kilos of wood replaces an average of 1 kilo diesel fuel.

It makes no difference whether the wood is light-weight (soft wood) or heavy (hard wood). Only the calorific value, together with the water content is of importance as well as the fact that charcoal is formed during the gasification which is necessary for the process.

The design of a wood-gas power station depends upon the maximum power requirements, the course of power requirements and the quality of the wood used for gasification.

For the first development effort of a forest region or the first step of the sawmill operation other wood processing industries (or in fact industry of all types), as well as for the operation of irrigation pumps for agricultural purposes, the small electrogenerator sets are necessary. These are usually operated for only a few hours a day and are always switched off during the night. The necessary amount of wood is limited and therefore transport and storage are rarely a problem. In most cases the storage can be arranged in a way so that wood can be air-dried without additional equipment. Wood chipping is performed with simple, easy to handle machinery.

A small complete unit consists of a shed for wood storage, where the wood chipping equipment is also placed, a power station with gasifier, gas cleaning and cooling equipment electrogenerator set and electric switchboard, built as a compact unit on a common base. If desired, heat exchangers can be installed in this compact unit. Wood feeding is done manually by means of a small platform or a ladder. Such compact units are either stationary or mobile (depending upon the size and location of the unit).

An example of a mobile unit is shown schematically in Annex 1. It consists of gasifier (1), gas cleaning and cooling equipment (2), gas engine (3) with synchronous alternator (4) and the electric switchboard (5).

Large installations whose wood waste supply is readily available (or if additional wood waste can easily be located) are most often of the stationary type. These power stations are usually built within or near to sawmills or to other wood processing industries having large quantities of wood waste. Because of the size of these power plants, transport has to be mechanized and operation must be automatic and optimized to a high degree.

In order to achieve a high efficiency and a safe operation, the gasification wood must be chipped to a certain size, and at various thicknesses such as sawdust, splinters, bark etc. which all have specific degrees of fineness. This must also be accomplished given the moisture content of the wood waste. Gas cooling has to be treated carefully. The simplest way is to exchange the heat by means of fresh water which will be drained into a river. In all cases, of course, this will not be possible. If this is in fact not possible, a gas-air-heat exchanger will be used which is equipped with special water evaporation and condensation equipment. (Such heat exchangers, however, cannot be installed in the tropics for obvious reasons.).

One good cleaning of the electrostatic filter guarantees clean gas for the life of the gas engine.

Because of the large quantities of wood which have to be processed in the power plant annually the equipment for wood preparation, wood storage and wood feeding requires a considerable amount of space.

The afore-mentioned are illustrated in Annex II which features a power plant set up in Brazil (Amazon region) which operates strictly on wood waste from a nearby sawmill. It runs independently and could very easily be attached to another type of wood processing industry or be erected as a separate power plant in which case the necessary wood would be regained by reforestation.

The whole plant is built in rows in order to achieve a stand-by capacity for all relevant parts. It was designed to accomodate

additional working space (according to energy requirements, etc.) should this become necessary at a later date. Peak loads are considered the standard of measure for gasification equipment as well as gas engines and electrical equipment. The wood preparation equipment, however, can be built according to the average load.

The wood storage yard is part of the wood preparation equipment. If the available wood is sufficiently dry and hogged into coarse chips it can be used without further modification (most often, though, the drying and hogging either have not been done at all or incompletely). Hogging is done, of course, with a hog (25) and this aparatus handles logs of up to 3 metres in length making them the right size for gasifiers. A mobile conveyor belt (24) either loads coarse wood chips into an intermediate storage (23) area or directly into a wet chip storage. From the intermediate storage (23) the wood chip flow is handled by a conveyor belt (22) onto the wood chip drier (21). Waste heat from the engine exhaust or this in addition to burnt gen-gas from a combustion chamber (20) will dry the wood to the desired moisture content. The wood chips, now ready for use are transported by a conveyor belt (26) to the dry chip storage under a shed.

Wood chip distribution into the feeding hoppers (1) and elsewhere inside the plant is performed by means of a frontloader (27) which can be wood gas driven as well. This is the least expensive and most simple method of wood chip distribution.

Wood storage and preparation requires a considerable amount of organization so that the wood is suitable for gasifiers and available in the necessary quantities. If the wood comes directly from the forest the amount of wood ultimately processed will be increased along with an extension of the hogging equipment. Considerable reductions in wood processing will occur, however, when wood waste is gained from production processes only (i.e. those having been geared for processing of wood waste).

Engine speeds are chosen with a long life envisaged for the gas engines. For instance the engine speed was 1200 rpm for a 560 Kw mech engine which had a diesel power of 764 kW. The gas engines operate by means of elastic couplings three-phase, self-

excited and self-regulated syncronated alternators. The heat from cooling water and lubrication oil is usually extracted in radiator-coolers (air) or in heat exchangers (water). Exhaust gas is collected in an exhaust manifold (11) and transported to the drum drier (21). If the drier is not operating a silencer reduces exhaust noise.

The generated electric power is (by means of cables in cable ducts - 14) furnished to the switchboard (15). Part of the power is converted by means of a transformer (16) to low voltage current for use inside the plant (chipper, conveyor belts, drier, gas blower, electrostatic filter, lighting and all switching and regulation purposes). Electic switching is done in a powerhouse (17).

The plant described above has only a limited demand for waste heat for wood chip drying. Often the wood processing industries connected to the power plant are in need of more heat for production purposes. Temperatures of up to 85° C can be gained from the cooling water and up to 100° C and more from the exhaust manifold by using thermo-oil. Heat exchangers are positioned as near to the gas engines as possible. For emergency operation - when the industry cannot make use of the waste - additional heat exchangers to air or water have to be installed, otherwise electricity production cannot be guaranteed.

The wood gasification process begins by filling the prepared wood into the feeding hoppers (1) and from there it goes to a special device for wood chip transport (2) and into the gasifier (3). In this cylindrical container the wood chips fall according to their particular weights and are gasified by adding air in certain quantities. Wood and air feeding is performed automatically. For starting up the air is sucked through the outlet opening by means of a battery operated blower (4) and the wood is ignited inside the gasifier. After some minutes a combustible gas is generated and when sufficient for the operation of a gas engine the starting blower is stopped and another gas blower (8) operated by a diesel engine is switched on. Now the gas runs through the multicyclone (5) where rough cleaning takes place. In the next phase the gas-cooler (6), it is cooled beneath the dew point by fresh water and thus the gas is cleaned by means

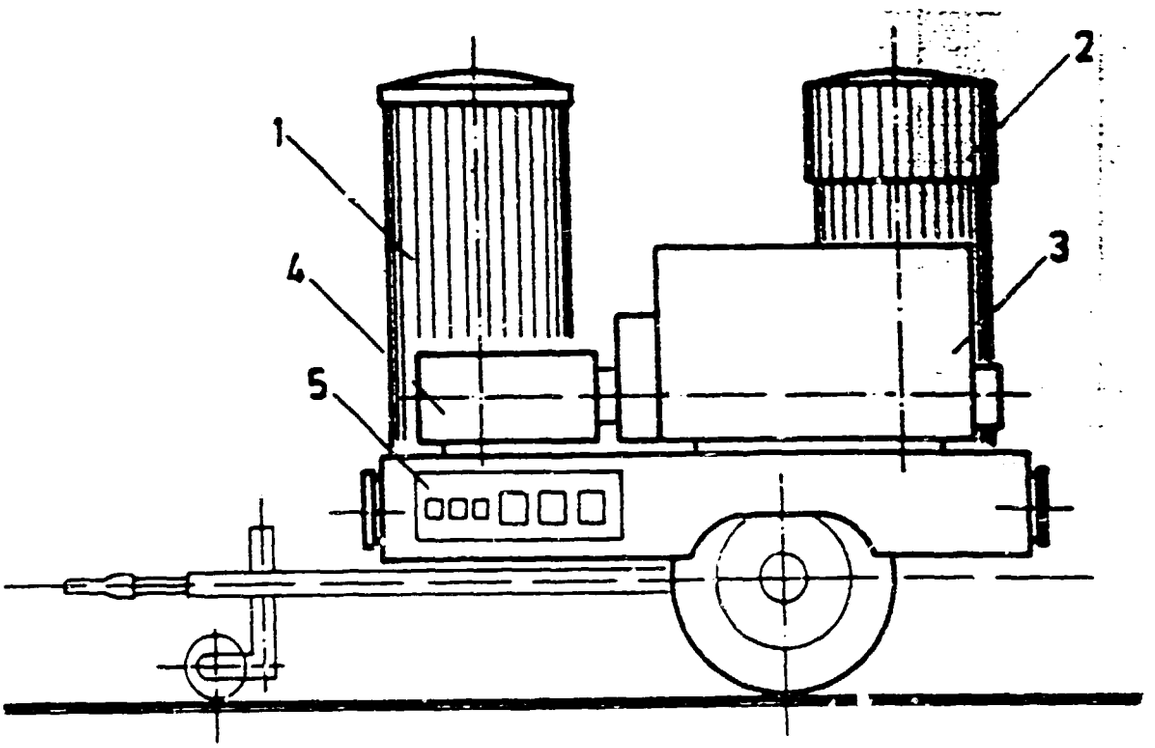
of condensation. Finally the gas is cleaned in an electrostatic filter (7) where even the finest dust particles are separated. This type of filter is nearly maintenance free since cleaning is done automatically by the fresh water and eletric power consumption is very low. The gas blowers (8 + 9) fill the gas with a constant pressure into the gas balance containers (10). As soon as electric power is available the diesel powered blower (8) can be either switched over to gas operation or switched off entirely and the electrically driven blower (9) can be switched on.

The constant low pressure in the gas balalce containers (10) increases the efficiency of the gas engines and improves regulation. The gas can as well be burnt in gas burners (20) without additional equipment simply by means of a gas pipeline.

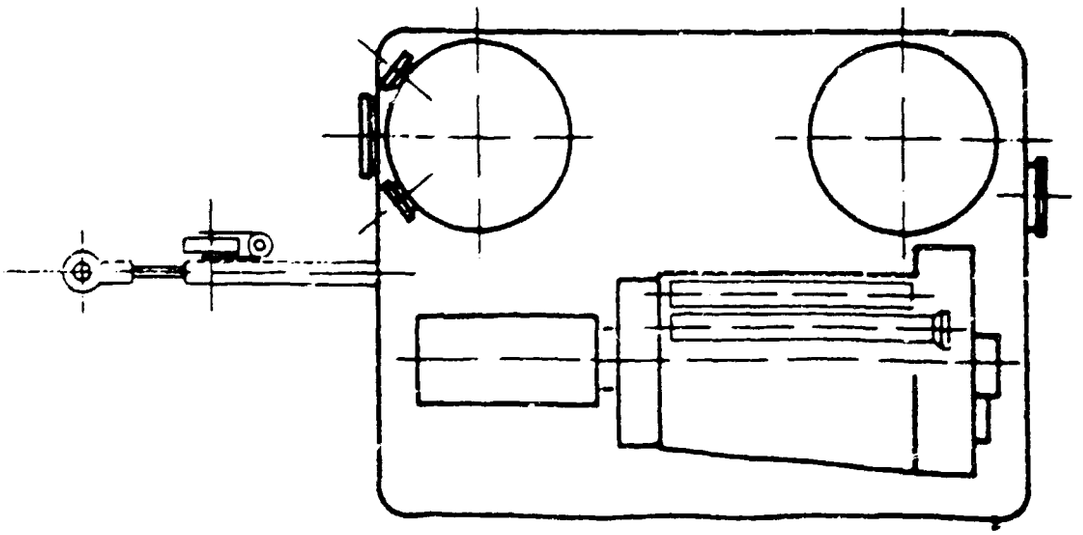
The air for the gas engines is cleaned by air filter (12) in order to separate dust and sawdust. The gas engines (13) are of the suction type and have enough section power to suck the gas through the gas-air-mixers after start up. Turbo operation is possible as well, resulting in a higher efficiency of the plant.

ANNEX I

SMALL SCALE POWER STATION UP TO 60 KVA



1. Coarse Chip Gasifier
2. Gas Cooling and Cleaning
3. Motor
4. Electric Generator
5. Controls



ANNEX II

POWER PLANT OPERATING ON WOOD WASTE