# Possibilities of processing agricultural waste at energy efficient facilities to produce gas, liquid and solid energy products

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**Abstract.** Comparatively, the results of experimental studies of pyrolysis of bio-plant material and oil sludge were studied, which gave similar results. The article provides scientific and technical information on the problems of processing solid waste and residues of biological origin. It has been shown that by thermal destruction, it is possible to obtain hydrocarbons of a gaseous, liquid consistency, and solid mass, preferably consisting of hydrocarbons with a small number of hydrocarbon residues.

## 1 Introduction

Now carbonaceous fault materials are estimated as one of the possible additional sources of energy. Using the rests, materials, and wastes of an organic origin will allow separate areas of the Earth to satisfy a significant part of energy and energy sources needs. In this connection, the important meaning is obtained by the geography of accumulating the rests and waste. In forecasting the energy potential of the rests and switching wastes, it is necessary to mean that a source of energy can be only an organic part of the rests. In this case are meant not only products of a biological origin, as at least 10 % of totals of the agricultural and urban rests in the world represent combustible materials. For the reception of energy, the part of the combustible rests because its non-uniform distribution can be used only. The necessary exact data on rates of biological waste accumulation and their quantity, as a rule, are absent. When mankind feels exhaustion of traditional natural sources

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hydrocarbon of raw material being in basic potential energy sources, it is compelled to address alternative sources. To such sources, it will be possible to attribute potential hydrocarbon waste of a biological origin, which represents high power value. It is known that mankind, at an initial stage of development for the first time, addressed wood as a source of energy sources. The not qualified usage of wood as a source of energy limits the scales of its application. The processing of wood material with a reception from its pyrolysis of gas, pyro-condensate, and pyrocarbon opens new opportunities for its qualified use. On the preliminary settlement data, it is visible that in case of use of pyrogas and pyrocarbon in quality energy sources in the scale of the republic, it is annually possible to receive 4 million tons of liquid hydrocarbon, only at processing petiole - stalks of the basic technical culture cotton plant. Potential of petiole annually in October - November (after the tax of a clap(cotton)) is estimated to be more than 100 million tons. Thus from this kind of withdrawal, with the technology developed by us, it is possible to receive 9 million tons of pyrogas (fuel combustible gas) and 12 million tons of pyrocarbon.

Similar approaches in many countries already give production. For example, in Turkey already in a home market has appeared in significant volume a biodiesel engine - product pyrolytic of processing of biological organic materials. In Ukraine, the construction of the large complex for the reception of biodiesel fuel from a one-year plant - rape is finished. As the charged large territory is radioactive and most fruitful in agriculture the attitude, the government of the republic has accepted the decision on rational use of this territory. Now are going to fruitful weight rape, which will be directed for processing with the purpose of reception from him of biodiesel fuel. This biodiesel engine shortly will appear in the home market of Ukraine - having released the huge potential of traditional diesel fuel, which will be directed on export. At the power summit held in Bonn (Germany) in 2004 by the highest tribune, the appeal about the necessity of intensive development of manufacturing energy sources from materials of a biological origin sounded. As in plants in very significant quantity, the energy of the Sun has accumulated the qualified reception by processing these materials carries on a global scale energy-ecological and economic interest. Therefore within the framework of applied scientific-technological research, carried out by us, the tasks by definition of technological parameters of process pyrolytic of a method of reception of a fuel fraction from a stalk cotton plant and development of the technological circuit of a method of reception low hydrocarbon, gaseous and liquid consistency were put. It is known that in the Republic of Uzbekistan, the need for a home market for energy sources only in motor transport is more than 9 million tons per year. Of these, 6.5 million tons are necessary for petrol and 2,5 million tons for diesel fuel. Besides the need to diesel fuels show also agriculture and railway transportation. To generalize all diesel fuel needs, they are estimated at less than 3 million tons per year. At the same time, potential of petiole (stalks of cotton plant) could ensure (supply) a home market to these quantities of biofuel received based on our technology. But because of the disorganization of conducting work, petiole in the agricultural fields are irrevocably lost. The little part of this petiole is used by the private sector in quality, low-grade fuel in village places. The experts in the long term share of biomass in electrical energy will reach about 10 % and manufacture the heat of 20 percent.

Every prospect for internal combustion engines in the future is opened by the use of synthetic fuel received in process gasification from the waste of a tree, agriculture, and coal. On the literary data, it is known that at the end of 2003, in Saxon Freiberg manufacture "SunDitstl", synthetic diesel fuel from biomass began, which reduced harmful emissions by approximately 50 percent. Proceeding from this, at the performance of the applied scientific-technological project, the jobs on reception pyro-condensate, appropriate fuel fractions, and the creation of skilled laboratory demonstration installation were stipulated. At the successful decision, the realization of a question of reception in frameworks innovation of the program will ensure in the accelerated rates to create a skilled pilot installation, which will be given to Government of Republic putting forward complex qualified use of all elements cotton plant in branches of economy. However, the opportunity to use these potentials is not so obvious; the questions having serious scientific, technological, and applied meaning (importance) will not be decided(solved) yet. In part pyrolytic by reception liquid hydrocarbon, replacing traditional hydrocarbon fuel (energy sources) and education of separate ecologically responsible(crucial) connections and if necessary managements of these processes for maintenance of observance of limiting allowable norms of emissions, and also thermal, thermodynamic and thermochemical of aspects pyrolytic by reception liquid hydrocarbon of components. In parallel, there is a necessity in management of processes concerning real technologies of reception pyro-condensate, proceeding from technological, power, ecological and economic opportunities of the republic, that predetermines necessity of development of original and optimum technologies of transportation, preparation, and processing of raw materials. As it marks, in the references, in the world already there are receptions of a biodiesel engines from various materials. However, reception from stalks cotton plant of petrol fractions anywhere yet are not engaged. The incidental jobs especially are developed with reference to those plants, which do not respect our culture. It is possible to result in acknowledgment stated such subject example, that the technology pyrolytic of processing Rape is the processing of vegetative fiber. Because rape in the structure contains up to 20 % of vegetative fiber. And in our case - concerning the cotton plant, such technology and such process is not applicable at all, as in cotton plant (stalk cotton plant), up to 22 % of weights contains cellulose and is practically absent of vegetative fiber. In view of the above-stated facts without own development, it is impossible to take into account features of raw material and technology of its processing, practically projects acted from outside without certification, and respectful to local raw resources.

## 2 Methods and Materials

Recycling more than 30-35 million tons of stalks cotton plant (approximately fourth part of potential) per year has a large energy-ecological meaning. Besides, the power capacity of this raw biological material makes more than 40 kcal and 200 million $nm^3$ of natural gas. Thus, the part of energy pyrogas and pyrocarbon can be spent to provide energy itself pyrolytic of process, then from the economy of traditional petrol fractions, accordingly will allow her on export, that at the world prices for diesel fuel on 1 t. 700 USD, even at the export of 3 million tons, makes

200 million US dollars annually.

During the implementation of this applied scientific and technological project, the modes of the process were studied with the determination of optimal parameters such as the effect of temperature, process duration, the effect of fillers, residual air content, in an oxygen-free environment, the effect of moisture, and other parameters affecting pyrolysis. This made it possible to determine the optimal conditions under which the required intensity of pyrolysis is achieved, clarify what the solid residues will represent after pyrolysis, and preliminary clarify some questions regarding the concept of the basic technological scheme of wood pyrolysis in relation to various technological conditions.

The following stage carries out research by definition of conditions of the minimal output soot aerosol at pyrolysis of stalks – petiole of cotton plant (the chemical composition of which is presented in table 1).

**Table 1**. The chemical composition of the petiole.

| № | Element | Petiole | Bark petiole |
|---|---|---|---|
| 1 | Carbon | 52.60 | 49.70 |
| 2 | Oxygen | 40.10 | 39.30 |
| 3 | Hydrogen | 7.00 | 5.40 |
| 4 | Nitrogen | - | 0.20 |
| 5 | Sulfur | - | 0.10 |
| 6 | Ash | 1.31 | 5.30 |
| 7 | Heat of combustion, kJ / kg | 22300.00 | 19420.00 |

To our great regret and surprise, this richest potential - cotton stalks - has not been dealt with enough until now. The mechanism of pyrolysis of bio-plant mass is as follows. In the bio-plant mass's combustion process, it decomposes with the subsequent oxidation of the decay products. As it heats up in a combustion chamber or other device, the biomass is destroyed: volatiles are separated, and a carbonaceous substance with a high content of mineral compounds remains. Volatiles contain CO, $CO_2$, some hydrocarbons, and $H_2$. The condensed part of the volatiles contains water and low molecular weight organic compounds such as aldehydes, acids, ketones, and alcohols. The resin fraction contains high molecular weight sugar, furan derivatives, and phenolic compounds. For example, during the pyrolysis of wood (450-500 ° C), several substances are formed, such as charcoal, liquid, and gaseous hydrocarbons. Pyrolysis or thermal decomposition of biomass occurs at sufficiently high temperatures with the formation of a mixture of combustible gases that burn with atmospheric oxygen. Low-temperature pyrolysis produces a significant amount of carbonaceous residue. Energy technological processing of pulp is equivalent to using 0.25-0.5 liters of liquid fuel oil (wide fraction) per kilogram of wood. Taking into account the simultaneous production of products of an alternative renewable energy profile, a qualified approach to the processing of this type of raw material makes it possible to organize production at a level comparable to modern chemical or petrochemical processes. 1.5 m3 goose-share> 540 kg dry matter> 135 liters of diesel fuel. This job has allowed estimating an opportunity study of the process, of course, a dry distillation of stalks cotton plant, both in bare a condition and with bark. The such experiment has given the specified parameters influencing an output of a target product. As the investigated

process is directed on receptions in the maximal contents pyro-condensate with an interval of boiling to the appropriate interval of boiling of petrol, for us, the increase of the contents low-boiling low molecular weight of connections in pyro-condensate is not expedient. Although always and in all cases, raw material processing of hydrocarbon with low molecular weight are more preferable.

In this case, the project's performance is directed on the reception of a petrol fraction to us more favorably to be guided by this parameter. The analysis of results has allowed us further to develop to us the basic technological circuit pyrolysis of the process, which will ensure an output pyro-condensate in a maximum quantity and qualitatively to receive with an interval of boiling appropriate on an easy fuel fraction. Besides, the received results form the basis for drawing up a complete representation of the possible technical and technological decisions at the realization of process pyrolysis and the choice of a necessary type of device. Methods of management of process pyrolysis, directed on the maximal parity of reception pyro-condensate, are also established.

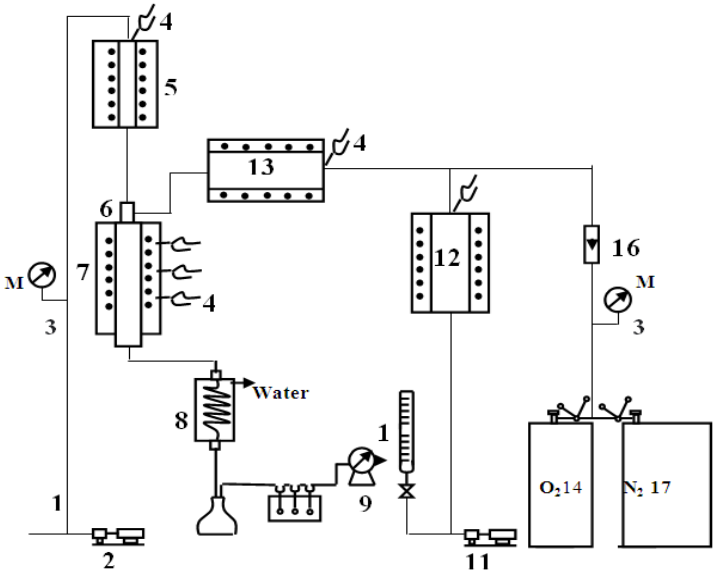


**Fig. 1.** Schematic of a laboratory setup for oxidative pyrolysis: 1 is burette for raw materials, 2 is pump for raw materials, 3 is reference manometer, 4 is thermocouple, 5 is raw material heater, 6 is mixer nozzle, 7 is reactor, 8 is circulating water cooler 9 is gas meter 10 is burette for water, 11 is dosing pump for water, 12 is steam generator, 13 is heater, 14 is oxygen cylinder, 16 is rotameter, 17 is nitrogen cylinder.

## 3 Results and Discussion

The results can be very important for the universalization of process pyrolysis concerning various biomaterial. The rather important stage at the performance of design scientific - technological job carries out research on minimization of education of ecologically harmful components at pyrolysis of stalks cotton plant

and other kinds of biological raw material. Here ecological part of the operation can be various. The first part is ecological questions arising from burning pyrogas and pyrocarbon for conducting pyrolysis of stalks cotton plant, i.e., autopyrolysis. Thus the accent is directed on the contents component of structure pyrogas and pyrocarbon. The second part of the question is more serious, as only conformity to an interval of boiling to easy fuel fractions of pyro-condensate parameters is insufficient. Here product should be certificated very strictly, with all gravity, and correspond to all parameters on the pretender of fuel according to State Standards. For example, it is possible to note that the education in products macromolecular paraffin hydrocarbon of boiling, taking place in an interval, results in an increase of temperature of hardening, that results in unfitness with use in the winter period. Other parameters can influence octane numbers. Acidity and the acid number are too concerned with such parameters, to which it will be necessary to concern very serious. If the first task is the reception pyro-condensate, the boilings, appropriate to an interval, of diesel fuel. And in the second stage, the product (fraction pyro-condensate) should sustain certification. Very probably in products pyrolysis as shown experience, are available propensity to tarring under influences of external natural conditions, that it is necessary to adjust and it is necessary to operate this process.

The scientific research job was spent in laboratory conditions.

Tables 1-2 below show the characteristics of a secondary material - raw material pyrolysis

**Table 1**. Chemical composition of the hydrocarbon part petiole

| № | Elemental composition, % wt. | Petiole |
|---|---|---|
| 1 | Carbon | 76.55 |
| 2 | Hydrogen | 14.11 |
| 3 | Oxygen | 6.16 |
| 4 | Nitrogen | 3.18 |

**Table 2**. Characteristics of the hydrocarbon part of broad fraction of(SHFN) pyrolysis products of the secondary material of organic origin (PPG)

| № | Temperatur e, ° C | aromatics Wt%. | | Naphthene Wt%. | | Paraffins Wt%. | |
|---|---|---|---|---|---|---|---|
| | | PPG | SHFN | PPG | SHFN | PPG | SHFN |
| 1 | 60-95 | 0.14 | - | 0.43 | - | 0.93 | - |
| 2 | 95-122 | 0.14 | 0.16 | 0.30 | 0.44 | 0.76 | 0.10 |
| 3 | 122-150 | 1.51 | 0.98 | 0.65 | 0.83 | 2.84 | 1.95 |
| 4 | 150-175 | 1.90 | 1.62 | 0.80 | 1.11 | 3.60 | 12.27 |
| 5 | 175-200 | 1.43 | 1.76 | 0.56 | 1.06 | 3.51 | 3.33 |
| 6 | 200-250 | 3.40 | 2.95 | 0.72 | 1.62 | 7.88 | 6.37 |
| 7 | 250-300 | 4.76 | 5.14 | 2.6 | 1.91 | 7.14 | 17.19 |
| 8 | 300-350 | 3.54 | 3.28 | 5.57 | 4.13 | 6.39 | 7.49 |
| | Total: | 16.82 | 15.89 | 11.63 | 11.10 | 33.05 | 44.24 |

## 4 Conclusion

The experimental results show that under certain conditions, organic materials by pyrolysis can get a huge fraction of hydrocarbons. Given the daily capacity of renewable organic part of municipal waste with a total capacity only for Tashkent, which estimated more than 1500 tons and multiplying it by tens of cities in the country, we can get large amount of organic material, which can be turned to energy and other byproducts. Annual renewal capacity of bio plant material - cotton stalks is more than 100 million tons, which is a big potential of the country. Therefore, it is essential to be considered for research for the development of new sources of energy. Below are the comparative results of the thermal pyrolysis of recycled organic material.

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