Kinetics of Filtration Drying of Biomass

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Abstract – Usage of fast-growing energy willow as untraditional source of energy has been showed in the article.

Key words – kinetics, drying, kinetic curves.

I. Introduction

Today there are known over 20 species of fast-growing plants, that can be used for obtaining of plants biomass. Such plants are eucalyptus, poplar, willow, miscanthus and others. In the temperate climate zone, in which Ukraine is, for the cultivation of energy crops the best species are fast-growing willow species *Salix Viminalis* [1] and others. The biomass of these plants is used to produce heat and electricity through pyrolysis or it can serve as raw material for the production of solid biofuels, including wood pellets and briquettes for households or industrial purposes.

Among all fast-growing energy plants willow is used as the main energy crops for solid biofuels. Leaders on the cultivation and use of biomass in industrial quantities for heat and power generation in Europe are Sweden, England, Ireland, Poland and Denmark. The largest plantations of fast-growing willow species *Salix Viminalis* today in Europe can be found in Sweden (approximately 18,000 - 20,000 hectares) and in Poland (over 6,000 hectares). In Ukraine, it grows in Volyn, Ternopil and Lviv regions, however, despite the large number of idle agricultural lands, number of industrial plantings of energy crops is not enough [2].

How energy willow influences ecology and environment:

– One hectare of energy willow plantations absorbs from the air more than 200 tons of CO_2 over 3 years.

– It is ideal for planting at contaminated and unproductive, in terms of growing crops, lands.

– It is effectively used in anti-erosion measures for soil strengthening.

– It enriches soil with minerals and trace elements, naturally occurred nutrients.

– Plantations of energy are natural filters for removal of agro-industrial production wastes, and are used as a buffer zone in the places of accumulation of biological farms wastes.

There are number of works devoted to research of possibility of using of fast-growing energy willow as an alternative energy source. Among the advantages of energy from biomass are the low cost of energy generation, environmental safety in terms of emissions into the atmosphere during its combustion. The ash formed during combustion, can be used as fertilizer in agriculture, in particular to fertilize wooden plantations.

Environmentally friendly thermal or electrical energy, which is accumulated during the photosynthesis and growth, can be obtained from the combustion of biomass. For the convenience of burning of grown biomass, storage and transportation, and also to provide mechanization of this process it is crushed and dried to 8.12% moisture and processed into pellets or briquettes.

It is known that the pellets have significant advantages over traditional fuels, as their production consumes about 3% of the energy, while in the oil production these energy costs are about 10% and electricity production - 60%, their calorific value is within 4.5 to 5.0 kW/kg, which is 1.5 times more than conventional wood and coal.

The combustion of 2000 kg of fuel pellets allocates the same amount of heat as in combustion of: 3200 kg timber, 957 m^3 of gas, 1,000 liters of diesel fuel, 1,370 liters of oil. Burning of wooden pellets in the furnace boiler is better - the number of residues (ash) does not exceed between 0.5 to 1.0% of the total fuel used. Burning of pellets do not affect environment negatively.

Due to the advantages of biofuels, as well as analyzing of theoretical and experimental data, it should be noted that fuel granules (pellets) are highly competitive compared to other traditional fuels.

II. Introduction

The study of hydrodynamics and kinetics of filtration drying was carried out on an experimental installation shown in Fig. 1.

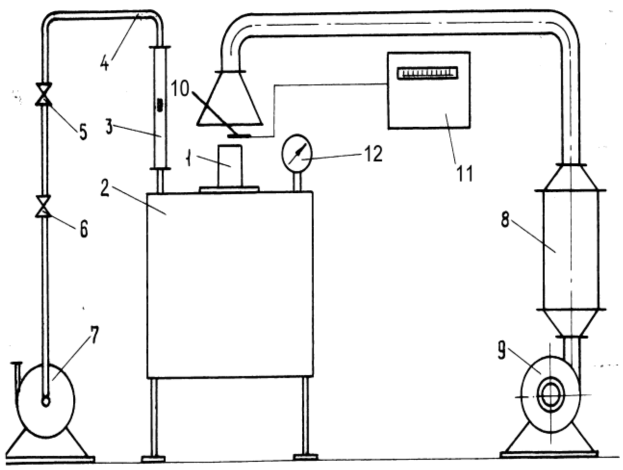

Fig. 1. Scheme of the experimental installation for drying of energy willow in a stationary layer of material.
1 - container; 2 - receiver; 3 - flowmeter; 4 - Pipeline System; 5.6 - regulating and shutoff valves; 7 - the vacuum pump; 8 - heater; 9 - fan; 10 - thermocouple; 11 - potentiometer; 12 - vacuum gauge.

Methods of experimental studies of fluid dynamics and kinetics are presented [3].

Research of hydrodynamic of motion of thermal agent during filtration drying, allows to calculate energy costs of the process.

Dependence of the pressure loss from fictitious filtering speed of thermal agent is shown in Fig. 2.

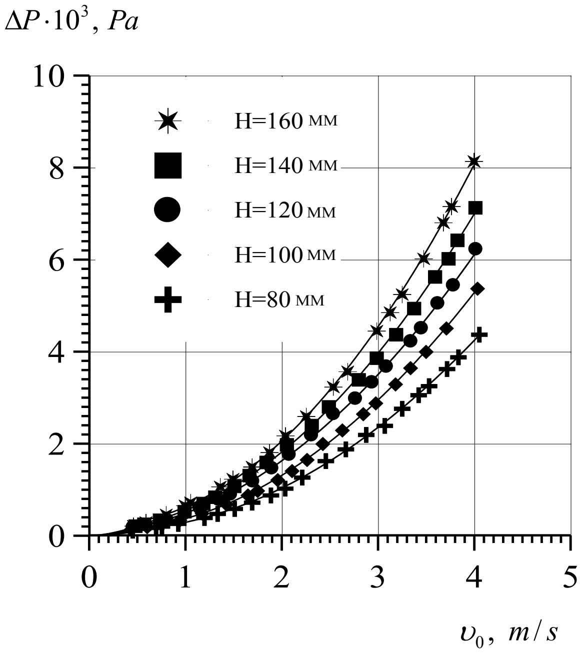

Fig. 2. Dependence of the pressure loss
in a stationary layer of chopped "energy" willow
from fictitious speeds for different layer heights

As a result of experimental and theoretical studies and for summarizing of data of hydrodynamic movement of heat agent through the stationary layer of energy willow we propose a criterion equation:

$$Eu = A \cdot \mathrm{Re}_e^{-n} \cdot \left(\frac{H}{d_e} \right)^m$$

and we found unknown coefficients of this equation.

Research of drying filtration kinetics allows to define the length of the drying process according to the parameters of the thermal agent and geometry of the test material layer, and set the dynamics of moisture containment in time and intensity of drying. This allows to calculate basic dimensions of drying units, their productivity and cost of energy for drying of moist material.

The results of experimental studies offiltration drying of energy willow are shown in Figure 3.

Conclusion

Hydrodynamics, kinetics and dynamics of drying filtration of fast-growing willow are studied during drying filtration.

Generalization of experimental research data as criterion hydrodynamics equations is proposed.

The dependence of filtration drying process from parameters of the thermal agent (drying capacity) and the height of the material layer is analyzed.

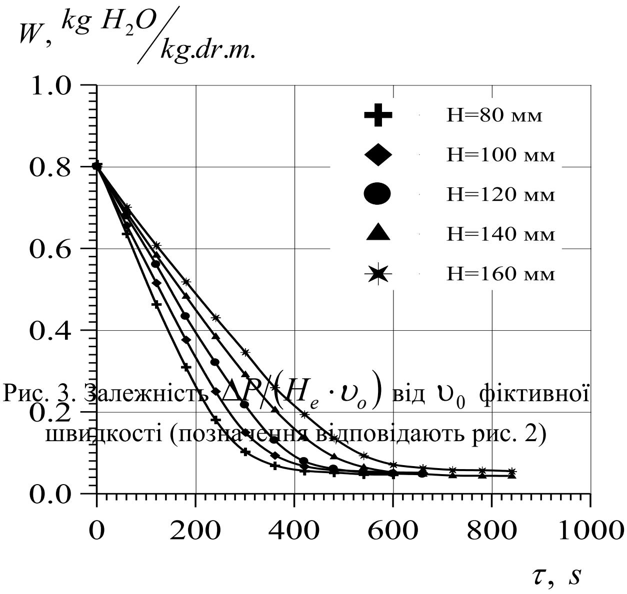

Fig. 3. Dependence of moisture from time of filtration drying. t=60°C; $\upsilon_0 = 1{,}6 \ \ m/s$

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