O. Kostiuk, Master student
O. Melnyk, PhD in Eng., As. Prof., research advisor
L. Mohelnytska, PhD in Phil., As. Prof., language advisor
Zhytomyr State Technological University

EFFICIENCY OF CROSS-RECUPERATIVE HEAT EXCHANGER IN SOLIDWORKS FLOWSIMULATION ENVIRONMENT

The use of renewable energy sources (RES) is constantly increasing due to the reduced negative impact on the environment and economic and energy feasibility.

In current economic and energy situation, industrial production, including construction materials, looks for ways to reduce the use of fossil fuels, such as coal, oil, natural gas. In Ukraine, the annual demand for energy resources is only 45% covered by domestic production and extraction of fossil energy sources. Energy independence can be achieved by improving the energy efficiency of manufacturing processes in the production of building materials and by using renewable energy instead of non-renewable energy resources that are imported into our country.

That's why in Ukraine and abroad 2 .. 500 kW heat generators for biomass burning are widely used in drying of building materials, agronomy, and so on. Such heat generators run on sawdust, granules, pellets, peat, wood and have different performance. For example, the company named MEPU has made its own assessment of efficiency of heat generators different fuels. The results are presented in Table 1.

Table 1. The coefficient of performance (COP) of MEPU heat generators using different fuels.

Fuel	**COP (%)**
Electricity	97,0
Gas	87,1
Wood pellets	86,0
Diesel fuel	81,6
Dry wood sawdust	80,5
Oil fuel	72,6
Coal	56,1
Wood	49,5
Peat	38,6
Raw wooden sawdust	35,1

The research shows that the energy potential of biomass in Ukraine is about 23.1 mln. tons of equivalent fuel per year. In this research work we use a biomass heat generators for heat-drying of kaolin in a rotary dryer (the size of the drum D=1.8, L=10 m). Primary kaolin humidity is 20%, the final 6%. To avoid pollution of kaolin by products of biomass combustion, it is proposed to use cross-recuperative needle-type heat exchanger for heating air (about 550 ^{o}C). Products of biomass combustion after leaving the heat exchanger and after undergoing cleaning equipment will be released into the atmosphere.

Taking into account heat used for drying (1560 kW) and heat capacity of the drying agent we calculated the required amount of drying agent and selected "Inka" heat generator of POV 1700 Brand (1700 kW thermal power). It is assumed that the flue gases have a temperature at the inlet of heat exchanger = t_{gas} 1100 ^{o} (data based on manufacturer of heat generator), output flue gas volume is V_{gas} = 1500 m^3 / h. Based on these initial data we modeled and calculated the needle heat exchanger for heating the air in the amount V_{air} = 1350 m^3/h to temperature 550^{o}C.

Model of needle cross pipe heat exchanger with distribution grid is shown in Fig. 1a. The material used for heat exchange pipes is chromium stainless steel containing 25% of chromium. It is assumed that the heat exchanger metal body lined with fireclay bricks.

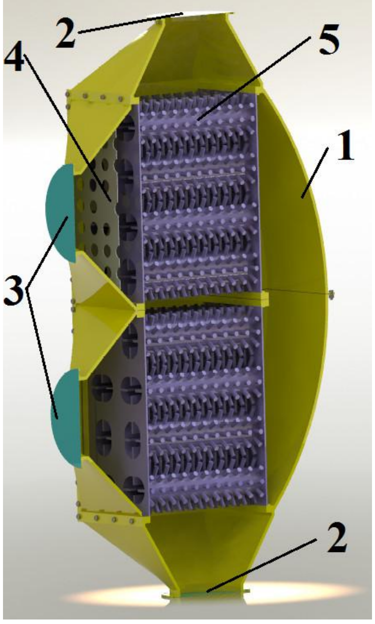
The simulation results in heat exchanger in SolidWorks FlowSimulation environment showed that the incoming airflow is not evenly distributed in heat exchange pipes (Fig 1.b). Most of the airflow passes through the heat exchange pipes, which are in the center. Therefore, to improve the efficiency of the heat exchanger it is recommended to install the distribution grid (position 4, Picture 1, a) for a more equal distribution of the incoming flow of air through the heat exchange pipes.

It is known that the efficiency of the heat exchanger can be calculated as follows:

$$\varepsilon = \frac{T_{hot}^{inlet} - T_{hot}^{outlet}}{T_{hot}^{inlet} - T_{cold}^{inlet}}$$

where T_{hot}^{inlet} - temperature of flue gas inlet, T_{hot}^{outlet} - flue gas temperature at the outlet and T_{cold}^{inlet} - air temperature at the inlet.

According to dependence (1) efficiency of the heat exchanger without distribution grids and with the establishment of distributive grating based on a number of simulation research with different air supply and combustion of biomass products was calculated. Installing distribution grid allows an average of 7-12% increase of the heat exchanger effectiveness.



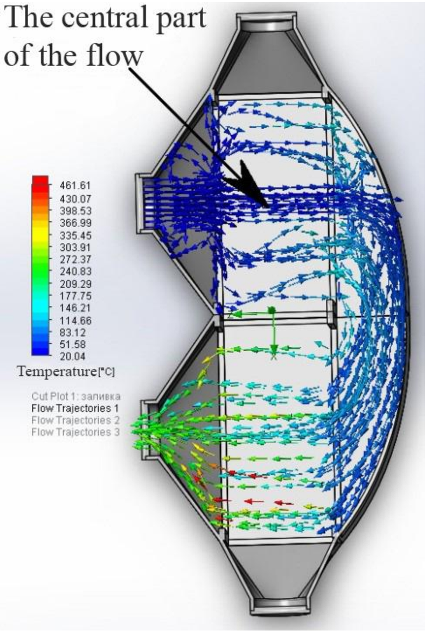


Fig 1. Cross-type needle recuperator: 1- corpus of recuperator, 2- the cover, which set the conditions and objectives of researching for input and output of combustion products, 3- the cover, which set the conditions and goals for research air input and output, 4- mesh partition to redistribute incoming air flow, 5- heat needle pipes.

On the other side installing distribution grating leads to the additional hydraulic losses. Hydraulic approximate loss is calculated as the difference between the pressure at the inlet and outlet (ΔP) by the following:

$$\xi = \frac{\Delta P}{pV^2/2}$$

where ρ - density of gas, V – velocity of gases.

To obtain the components of dependence (2) in FlowSimulation project we stated the relevant research objectives, namely, the pressure and speed of inlet and outlet air. After several researches with different air supply, it is found that after installation of distribution grating hydraulic loss increases with higher speed of the input stream. Generally, hydraulic losses increase by 5-10%.

According to the results of modeling it is determined that the recuperator heating surface must be at least 6 m2. The maximum, minimum and average values of the drying heat agent at the recuperator output are determined as well. They are pressure, temperature and flow rate, efficiency of the heat exchanger and hydraulic losses.

In general, the proposed measures (installation of grating for a more equal air distribution through the heat exchange pipes) can improve the thermal efficiency of the designed recuperator by 7-12%.