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В докладах представлены результаты теоретических и экспериментальных исследований ученых и специалистов Казахстана, Германии, России, США, Японии и Украины по направлениям: теплохладоснабжения, кондиционирования и экологии.

Сборник рассчитан на специалистов и ученых, работающих в областях пищевой, химической, нефтеперерабатывающей промышленностей, а также гостиничном бизнесе и спортивных комплексах.

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APPLICATION HEAT EXCHANGE EJECTOR FOR CONDENSATIONOF VAPORS OF HYDROCARBONS

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Inkjet machines are simple in design, as they work without direct costs of mechanical energy.

Ejectio and Injicio concepts of device for this kind are commonly use in the technical literature: an ejector (from Lat. Ejectio - delete), if it's is intended to remove the vapor (gas) or liquid out of the vessel and the working flow is supplied from the outside; and an injector (from Lat. injicio - Throws up) if the amount of vapor (gas) or liquid is injected into the vessel with help outlet working flow.Ejector heat exchanger (fig. 1) unit with a change in the aggregate state of flow is designed. Stream sucked air mixture with hydrocarbons accelerates ejector confusor to Mach 0.3. In the mixing chamber, workflow is injected(chilledhydrocarbons, carbon dioxide, inert nitrogen gas, a liquid). The instantaneous heat transfer occurs, and hydrocarbons condense at the outlet of the diffuser of the ejector. Heat extraction is conducted by contact heat exchange and evaporative cooling by injected into the gas stream of finely sprayedliquid cooled [4].

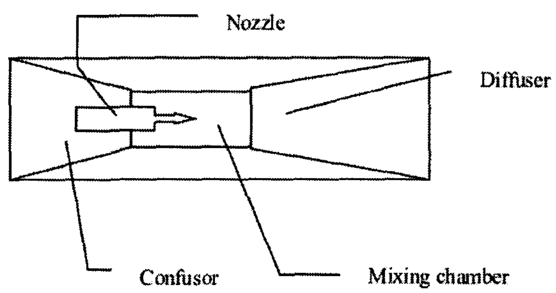


Figure1 - Heat exchanger ejector for hydrocarbons condensing.

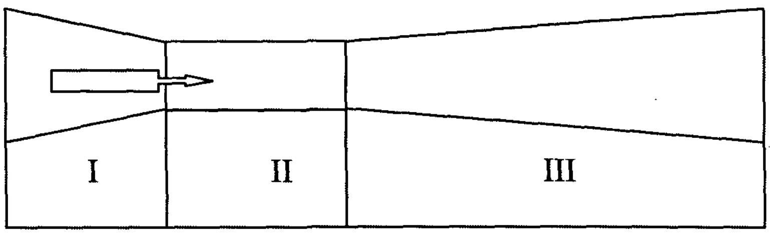
The heat exchanger ejector is a channel with the intensive heat exchange and phase transition inside at the expense of the finely sprayed liquid ejection to a superheated air and hydrocarbons mixture at a high range.The main flow is cooled as the working fluid evaporates, then the hydrocarbons condensation takes place inside the mixing chamber.

The calculation is based on the heat exchanger ejector laid the heat balance equation (during evaporation and condensation of the working substance from the main flow of hydrocarbons), the equation of momentum (quantity of motion)

The heat exchanger ejector simulation process is based on the heat balance and momentum equation describing the evaporation of working fluid and condensation of hydrocarbons main stream[4].

Heat exchanger ejector analysis

At the present time it is possible to representa phenomenological (physical) modeland explain the behavior of the stream in the apparatus.The air and vapor of low-boiling hydrocarbons of mixture enters to the heat exchange ejector at the high range, and the sub-cooled liquid is injected at a low speed and temperature. The most important phenomena in the process - is the frontal resistance of droplets,evaporation,channel wall friction and hydrocarbons condensation from the main stream.



Described these phenomena occur simultaneously (fig. 2).

Zone I. Air and vapors of low-boiling hydrocarbons gas stream acceleration, by narrowing of confusor(preparation for contact heat exchange).

Zone II. Active contact heat exchange between the main gas stream and the injected liquid (flash gas cooling).

Zone III. Stagnation of the flow and condensation of hydrocarbons from gas mixture (air is superheated and hydrocarbons are significantly subcooled)

Design and testing of heat exchanger ejector

A new method for condensation of hydrocarbon vapors in the stream represented in the work the heat exchanger ejector.

In order to establish dependencies condensation of hydrocarbons in the heat exchanger ejector from flow velocity and temperature of the working substance was an experimental study of the proposed unit on the designed stand by simulating real conditions of storage and overfilling of low-boiling fuels in Odessa at the company "Inzhmash Service Ltd".

Input parameters for the experiment are presented in Table 1 and Table 2.

Table 1 - Content of hydrocarbons in the air mixture depending on the temperature of environment during the overfilling from tank into the tank (theexperimental data)

Ambient temperature, ^{0}C	0 - 20	20 – 30	30 - 45
Gasolines conventional brands	5- 7%	7 -12%	15 - 20%
Diesel fuel (summer)	3- 4 %	5 - 6 %	8 - 10%
Bioethanol fuel	4- 5%	6 -10%	12- 22%

Table 2 - Temperature of the working substance injected into the main streamof air and hydrocarbons mixture

working substance	refrigerated hydrocarbons	carbon dioxide	the inert gas is nitrogen, as a liquid
injection temperature	(5-10)^{0}C	(-80--75)^{0}C	(-195--180)^{0}C

The main objective of the experiment is to confirmthefull condensation of hydrocarbons. The experimental stand consists of three tanks, connecting 100mm pipelines, heat exchanger ejector, two strain-gauge balances, liquid hydrocarbons pump (various grades of gasoline, bioethanol and diesel fuel) and an explosion-prooffan [1; 3] (fig. 3).

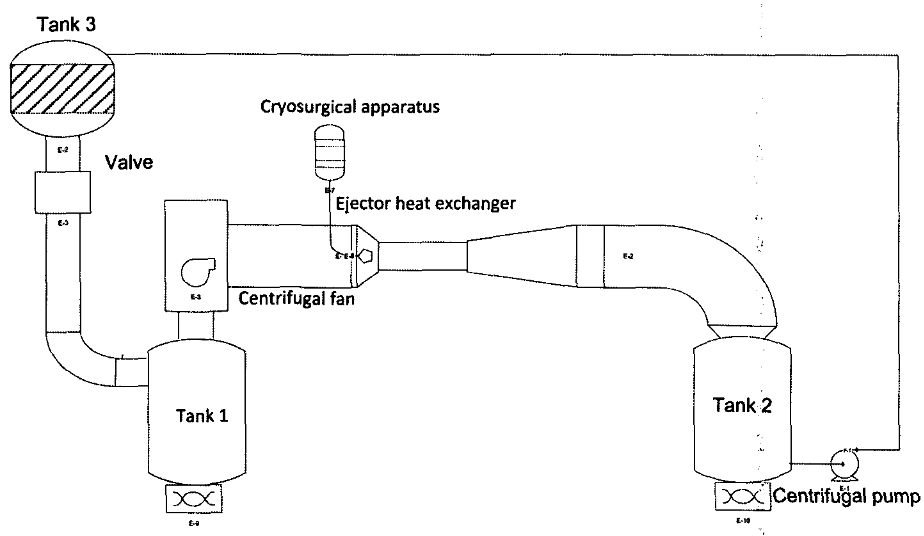


Figure 3 - Experimental setup refrigeration system in the stream of hydrocarbon condensation.

Two main tanksare installed and balanced. The third tank is placed above the whole system. Hydrocarbons are ducted from it to the Tank 1. It is possible to duct the liquid hydrocarbons to Tank 2 through the heat exchanger ejector with the help of centrifugal pump. To increase the motion speed of hydrocarbons there is a high torque fan installed before the heat exchanger. There is also a flow stabilization zone. Tank 1 is equipped with the electric heater. Liquid nitrogen is injected to the heat exchanger ejector by the capillary-type nozzle. Hydrocarbons flow velocity is control by the change of a rotational speed of the electric motor of high torque fan. TESTO-400 is involved in the work of experimental stand, allows carrying out measurements of temperature, flow rate, flow charge and weight changes. Volume of Tank 1and Tank 2 is 200 liters, Tank 3 – 30 liters. Capacity of the centrifugal pump is 10 liters per minute. Fan flow rate is 30 meters per seconds.Liquid nitrogen to 1 liter and working fluid of liquid hydrocarbons (various brands of gasoline, bioethanol and diesel propellant) to 30 liters were used in the experiment. Hydrocarbons were not preheated over 45°C. The fuel station conditions were simulated during the experiment.

The hypothesis of the heat exchanger ejector application for hydrocarbon condensation is checked out using the following methods:

1. Liquid nitrogen is ejected into the accelerated stream of vapor of hydrocarbons with the temperature -193°C;

2. The vapor nitrogen with temperature - 70°C ejected a vapor hydrocarbons flow with speed of 25m/s before the heat exchanger ejector;

3. Except nitrogen, the carbon dioxide is used as a working fluid in the open-cycle mode.

The experiment is carried out at the carbon dioxide cycle parameters. During the experiment the hydrocarbons are fully condensated and the amount of working fluid what is necessary for full condensation is determined. The rate of flow in a heat exchanger ejector is experimentally selected and matched to a Mach number M=0,3. Initial fuel temperature matched to 25-45°C.

Figure 2 shows the quantity change of working substance curves depending on the temperature in the camera of condensation of a heat exchanger ejector in which the full fuel condensationis made.

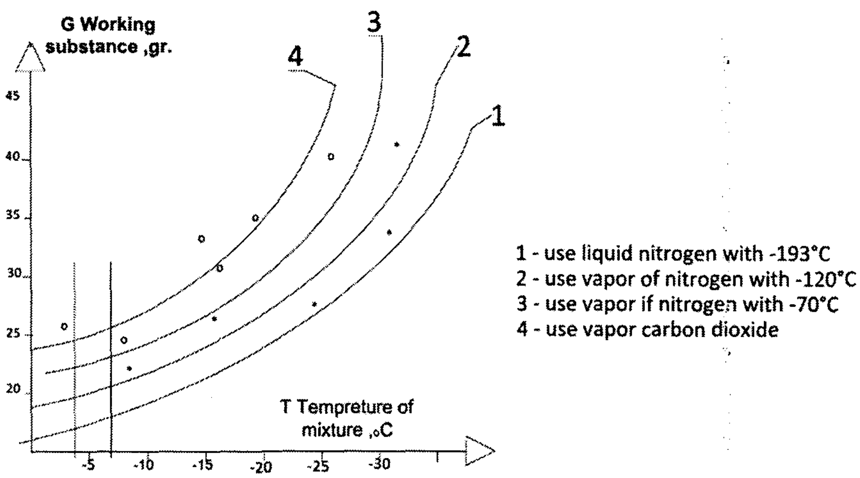


Figure 4 - Dependence of amount change of the working substance against the temperature in a heat exchanger ejector.

Results of experiment demonstrated that for spread brands of gasoline the condensing temperature is in the range (-7… -4°C), in dependence of seasons and brands of gasoline.

According thermophysical characteristics, condensing temperature of low-boiling hydrocarbon fractions is in the range (15-25 C). It is experimentally determined that the rapid fuel condensate fall from air occurs when the liquid sub cooling is in the range of (15-20°C)and the air is extremely superheated. Application of the heat exchanger ejector accelerates and improves the heat exchange between the working substance and a mixture of air and hydrocarbons.

Table 3 - Experimental data of the fuel temperature conditions

	Gasoline conventional brands	Diesel fuel (summer)	Bioethanol fuel
Ambient temperature which is more affective tothe fuel vaporization	30-40°C	40-45°C	25-35°C
Ambient temperature which is not affectiveto the fuel vaporization	15-20°C	25-30°C	10-20°C

Evaporation of low-boiling fractions of fuel in semi-open storage system is increased up to 1.5-1.7 times when achieving the upper range of temperatureand is decreased when achieving the lower range of temperature.

The R&D work included the problem analysis in operation practice and design of liquid hydrocarbons conservation systemsduring the transportation andtransferring it from tank to tank. The application of liquid nitrogen for condensation hydrocarbons from the air is profitable at flow rate of 20 - 40 grams per 100 grams of condensed fuel. The experimental results confirmed the relevance of nitrogen and carbon dioxide application for cooling the mixture of air and hydrocarbons of various brands of gasoline, bioethanol and diesel fuel for the hydrocarbons separation.

Essential advantages of the contact heat exchangers in comparison with the surface heat exchangers are the time of heat exchange and decreasing the overall dimensions, capital and running costs, increasing the reliability of equipment as well. Application of heat exchanger ejector provides ecological and fire-safety from hydrocarbons emission into the atmosphere. The relevant factor is the decreasing of bioethanol fuel components evaporation to ensure the safety of hydrocarbons and fuel qualitative indexes.

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