Experimental Study of Overland Moisture Condensation

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The content of water in the form of vapor in the surface layer of the atmosphere averages 11 g/m³ throughout the world and reaches 25 g/m³ or more in the tropical regions [11]. At a fast temperature drop and relative constant pressure and humidity, water vapor comes to saturation and the vapor excess falls on the surface as condensed moisture (dew).

In deserts and arid regions of the Earth with minimal precipitation, dew is the only contributor of water that gives life to plants and animals [2]. There are descriptions of ancient constructions built by man for vapor condensation from the atmosphere. The most famous are Feodosian constructions, which provided potable water in the Middle Ages to the city with a population of 80,000 [1, 3].

Water consumption in the world is growing steadily and has already reached 4000 km³/yr [9]. Water is gradually turning into a deficient natural resource. It is not accidental that the United Nations declared the year 2003 a year of fresh water. According to the World Health Organization (WHO), a half of the Earth’s population will suffer a shortage of fresh water by 2015.

In regions without natural fresh water sources, slightly saline and sea waters are freshened by means of distillation, electrodialysis, and reverse osmosis [8], which require much power consumption and pollute the environment with residual brine discharges containing a large amount of salts. Moreover, these methods of obtaining fresh water can be applied for waters with a TDS content of no more than 1%. Water contained in the atmosphere can be regarded as an alternative to these untraditional sources of fresh water. The total amount of water in the atmosphere is 14,000 km³, and this volume regenerates 45 times per year [11]. The problem is only related to the elaboration of methods for extracting this water.

This work presents basic results on the construction of an experimental installation for atmospheric moisture condensation, primary measurements, and observations over processes in the installation.

1. The following two conditions should be fulfilled to ensure condensation in the installation: (1) an intense flow of moist air through the system that can be provided by convection or breeze fluxes; (2) creation of a ramified surface whose capillary structure provides moisture condensation at relative humidity of 85–100% during the formation of meniscus inside capillaries.

Based on principles of the creation of such a system of moisture condensation [4–7], researchers at the Institute of Experimental Meteorology of NPO Taifun (Obninsk) constructed an experimental Rosa installation (Fig. 1) for studying the process of the natural overland condensation of water contained in the surface layer of the atmosphere for a practical use.

In the Kaluga district, where the installation was constructed, dew falls only three months out of the year. On such days, atmospheric conditions are similar to those in coastal zones or desert zones at night when the relative humidity reaches 100%.

2. Processes going on in the system were studied with the help of the following devices: thermocouples and moisture indicators for the measurement of temper-
Fig. 1. General view of the installation for condensation of atmospheric moisture.

Fig. 2. Profiles of the outdoor air temperature and temperature inside the system for the periods October 14–21, 2002, and October 21–26, 2002.
ature and air humidity inside the system; radiation temperature meter for remote measurements of temperature; infrared thermovision unit AGA-680 for the remote study of temperature fields; and MK-15 meteorological complex with an acoustic anemometer for the measurement of the vertical and lateral wind components and establishment of their direction, the temperature and relative humidity of air, and atmospheric pressure.

The installation was constructed in the second half of September 2002. Experiments and measurements were conducted from September 20 to October 25.

The measurements, carried out for a short period prior to winter cold weather, showed that the temperature of limestone debris drops to required critical points at night due to self-radiation of the structure and water vapor begins to condensate on the debris surface. Depending on external conditions and despite great fluctuations of the outdoor air temperature, the temperature inside the system slightly changes during some periods, whereas it is similar to the outdoor air temperature in other periods. Figure 2 demonstrates curves of outdoor air temperature and the temperature inside the system for two periods favorable for studies (October 14–21 and October 21–26).

It is worth mentioning that the system should be saturated with moisture so that meniscuses can appear inside capillaries and condensate can be formed. The productive capacity of the system was high only during three most favorable intervals within the whole period of observations. Figure 3 displays a curve of the system productivity of the Rosa installation in October 23–25, 2002.
productivity for one of the favorable periods (October 23–25, 2002) when it reached 1.3 m$^3$/day.

In order to study the air flow velocity inside the system, smoke was used as an indicator and released from the windward side in the middle of the structure at the surface level. The average velocity of air flow inside the system was equal to 0.3–0.4 m/sec.

3. Experiments conducted with the Rosa system model confirmed the basic possibility of the practical use of the natural condensation of atmospheric water vapor on a man-made ramified surface. It should be pointed out that climatic conditions of the Earth’s tropical and equatorial zones with a high absolute air humidity and daily temperature gradients exceeding 15°C are much more favorable for using the systems described above than conditions in the Moscow region. Under these conditions, our installation can produce up to 15–20 m$^3$ of water. Figure 4 shows regions where such efficiency can be reached. According to preliminary calculations, the cost of water produced by the Rosa system will be ~$ 0.20/m$^3$, which is five to six times less expensive than water produced by distillation.

REFERENCES