Vils-5 Vacuum Ion Beam System for Technological Use

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Abstract – The VILS-5 vacuum ion beam system having chamber volume 0.5 m^3 with limiting residual pressure 1.2×10^3 Pa is shown. The system is equipped by the source of gas ions which one is capable to irradiate the objects by argon or nitrogen ions with energy of 30 keV and density of ions dose 7×10^{13} cm^{-2} having big gassing under treatment about 5000 l/s at pressure 0.1 Pa.

1. Introduction

The application of ion-beam technologies in agricultural branch for increase of productivity of a crop in Russia and foreign countries is rather actual. In the paper the design of the vacuum system for genetic engineering in crop is offered. The results of the investigations are a small example of usage of the designed system in this area.

2. System Construction

The general form of the system is shown in Fig. 1. The system setup has the vacuum chamber with a volume 0.5 m^3, it is supplied by a door 500×700 mm^2 in size. In center of the chamber the desktop with the rotation engine is placed. There are 4 pans on the desktop with the irradiated surface of 480 mm in diameter. The pans are cooled by water with the cooling system of desktop. Each pan is filled up by crop and is allocated under of gas ions using swinging mechanism.

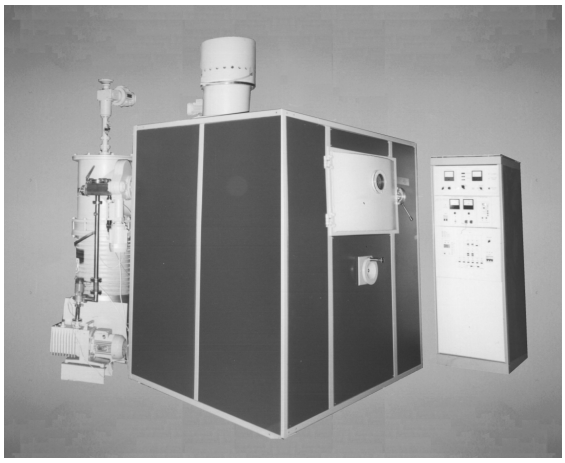

Fig. 1. General view of arrangement

For ion-beam treatment of biological cultures and crops by the way of suspensions, which one are possible to place in vacuum only short time, the lock chamber with input mechanism of pans of 80 mm in a diameter is added to vacuum chamber.

The scheme of a vacuum system is shown in Fig. 2. The forvacuum pump-down of the chamber is made by the vacuum aggregate AVR-150. The high-vacuum pump-down of the chamber implements two oil pump NVDP-400 with cold catch pots. The vacuum traps can be cool by water or refrigerant using in refrigerating units. The shutters D_y 380 are applied for the separation of evacuated chamber from the pumps. A gate valve and cold catch pot have the original designs. Ballast tank (10 liter in volume) are established on oil pumps output for long time of pumps activity in no-operation mode.

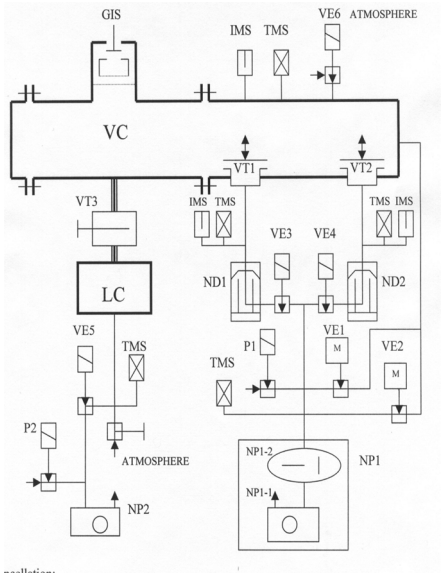

Fig. 2. Vacuum system circuit

An evacuation vacuum system and operating by it enable to use the high-vacuum scavenging of vacuum chamber by one or two oil pumps. The activation of the second pump can be made at any stage of high-vacuum scavenging of the chamber.

The operating of vacuum system provides reliable protection of vacuum instrumentation against unauthorized operation of initiating item of the electrical feed circuit. The interlock of high vacuum in the chamber implements by the blocking vacuum gauge 13VT3-003, which regulate the opening of the high-vacuum shutters. A vacuum gauge controls the pressure in forvacuum system of scavenging using the converter PMT-6-3.

In designed vacuum system the operating by high-vacuum pressure in chamber is made by an automatic system of letting-to-gas which one has the ionization vacuum gauge and electronic control block of gas leak. Ionization converter PMI-51 can be used as a control element in an automatic system, and the electromagnetic valve with the dosaging opening of letting-to-gas can be used as actuating element.

The control is made under the scheme of automatic feedback of pressure and gas leaking within the limits of 10^{-2} … 1 Pa. The necessity of this automatic system is connected with the technological use of the system. At ion-beam treatment of objects having organic agent, there is unchecked outgassing, which level changes during all on-duty time of the ion beam. Keeping constant pressure which one is adjusted of working gas volume in vacuum chamber guarantees the stable operation of ion source in this condition.

Vacuum chamber, desktop and evacuation system are made from the stainless steel. The hermetic sealing of all vacuum plug contacts is made with using rubber vacuum seals.

The vacuum system is supplied by wide-aperture high-energy source of gas ions continuously operated [1]. Technical parameters of ion source are following: energy of ions is 10 … 30 kV, operating ion current is 10 … 20 mA, current density on the target is 0,012 mA/cm^2, area of uniformly processed surface is 1800 mm^2, working gas is Ar, N_2 or other inert gases. The time of continuous operation of source is 8 hours. It allows treatment full-and-down 4 pans with dose $\sim 5 \cdot 10^{17}$ cm^{-2}. The ion beam source is specially designed for processing of objects with high-level of outgassing.

The power supply units together with the controllers of vacuum system and source of gas ions are built in one common electrical unit.

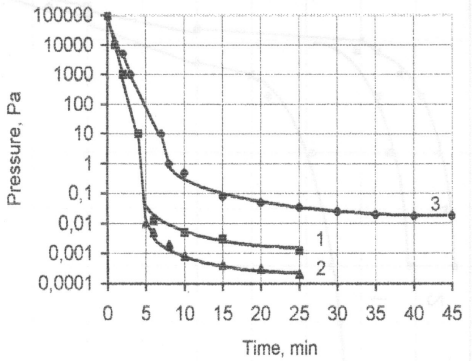

Fig. 3. The pressure into vacuum chamber depending on time of evacuation up to residual limit pressure: 1 – with cooling of the trap by water, 2 – with cooling of the trap by a fluid freon, 3 – with cooling of the trap by water and full filling of pans by crops

3. Experimental results

The rate of evacuation of vacuum chamber was investigated at different operational modes of the system. The results are shown in Fig. 3. Measurements of evacuation time of the chamber were carried out up to limit pressure without objects of ionic processing and with agricultural cultures.

At creation of system it is very important to preserve the of agricultural cultures robustness after effect of vacuum and thermal effect by ion beam. The experiments were carried out with semen of wheat.

Semen of wheat had humidity no more than 12%. When semen of wheat was placed in 4 pans in one layer (400 g), the time of evacuation of the chamber up to limiting pressure increased sometimes. Experimentally it was established that vacuum effect for 4 hours results in a decrease of humidity to ~ 8%. The robustness of semen is saved at these values of humidity. The ion-beam treatment decreases the time of reaching of the same humidity up to 2 hours. The increase of current density of ions source to decrease the time of dose accumulation and thus decrease the vacuumize time leads to the destruction of surface layer and semen embryo. Experimentally the optimum regime of activity for the system with placed objects was determined: an operating pressure is 0.02 Pa, first passage time of operating pressure no more than 45 min, ion beam density no more 0.01 mA/cm^2 at ions energy of 30 keV.

4. Characteristics of the Designed System

P_{lim} with cooling of vacuum trap by water	$1.2 \cdot 10^{-3}$ Pa
Roughing time P_{lim}	25 min
Volume of the chamber	0,5 m^3
Critical dimensions	2.5×1.8×2.1 m
Ions energy	30 eV
Current of ions beam	20 mA
Working gas	Ar, N_2
Diameter of ions beam	480 mm
Quantity of treated objects	4
Consumed power	up to 8 kW

Conclusion

The capabilities of VILS-5 system allow carrying out ion beam treatment of organic and inorganic stuffs.

References

[1] Yu.N. Paraev, V.P. Yanovskii, "Technological wide-aperture source of gas ions", *this proc.*