Vacuum System for the Dubna ECR - Ion Source DECRIS - 14

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Abstract

At the Flerov Laboratory of Nuclear Reaction in Dubna an ECR - ion source DECRIS - 14 (Dubna Electron Cyclotron Resonance Ion Source) is being built on the 14.5 GHz. The main features of the source vacuum system, which is based on the turbomolecular pumps VMN - 500 (Russia) are described. The influence of the magnetic field leakage from the source on the work stability of the turbomolecular pumps is also given.

1. Introduction

The vacuum system is one of the main component of the ECR ion source. Basically, it consists of stainless steel, copper, steel and duralumin beam tubes pumped with turbomolecular and rotary pumps.

The paper gives a rather detailed description of the vacuum system of the DECRIS - 14 ion source [1] and the influence of the magnetic field leakage from the source on the work stability of the turbomolecular pumps.

2. Pumps and Gauges

One main and two auxiliary pumping units are used providing clean, safe pumping with pressure monitoring the ion source. This is designed in order to produce an average dynamic pressure of 10^{-4} Pa. Basically, it consists of 7 cm dia stainless steel, 4 cm dia copper, 10 cm dia steel and 4 cm dia duralumin beam tubes pumped by a combination of the 500 l s^{-1} turbomolecular pumps (VMN - 500) and the rotary pump (BL - 90). The pumping units are spaced at about 1.5 m intervals and contain besides the pumps, high vacuum gauges, electrodes and various beam diagnostic elements. The total length of the high vacuum beam tubes is about 3 m.

2.1. Main and Auxiliary Pumping Units

The scheme of the vacuum system is shown in Figure 1. It is designed to pump the ion source area, the beam line and beam diagnostic cubes C_1, C_2 and C_3, respectively .

Two rotary pumps are operated in order to produce the forevacuum (BL - 90 and NVR - 5 with the pumping speed of 90 m^3 h^{-1} and 5 m^3 h^{-1} at 0.1 MPa, respectively). The NVR - 5 forepump is used for slow - acting evacuation of the ion source before connecting of the turbomolecular pumps. The BL - 90 is the main forepump which is continuously pumped the whole system.

Proceeding from the dimensions of the vacuum system effective pumping speeds S^i_{eff} of the vacuum units are calculated in the cross sections S_1, S_2 and S_3. It holds that: S^1_{eff} = 30 l s^{-1}, S^2_{eff} = 20 l s^{-1} and S^3_{eff} = 200 l s^{-1} for air at 1.2×10^{-5} Pa, respectively. The reduction pumping speed of the turbomoecular pumps is mainly due to the small

1,2 FIRST AND SECOND STAGES OF THE ION SOURCE
3 EXTRACTION ELECTRODE
4 FOCUSING ELEKTRODE
5 BEAM TUBE
6 DOSING VALVE
7 MANUAL DRIVE
8 ELECTRIC MOTOR DRIVE
9 THERMOCOUPLE GAUGE
10, 11 IONIZATION GAUGES
13 PIRANI GAUGE
14 SOLENOID VALVE
15 ROTARY PUMP
16 TURBOMOLECULAR PUMP
17 ELECTRIC MOTOR DRIVE
18 FLEXIBLE TUBING
19 PIRANI GAUGE
20 SOLENOID VALVE
21 ROTARY PUMP

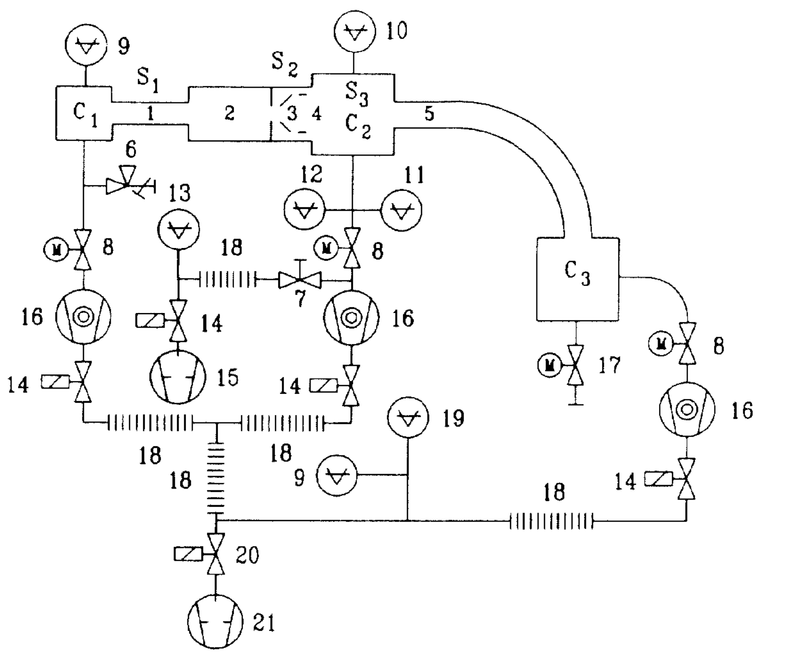

Figure 1. Scheme of the main and auxiliary vacuum units.

diameter of the vacuum beam lines.

2.2. Leak Tightness, Bakeout and Outgassing Rate

After 20 h of pumping the leak rate of the vacuum system is below 5×10^{-3} Pa l s^{-1}. The standard leak test where helium is applied for about 1 min at slight overpressure does not show any leaks (detection limit is 2×10^{-9} Pa l s^{-1}).

The best vacuum condition are obtained after 200 h pumping. After this time and after three mild 5 h bakeouts the outgassing rate and leakage of 2×10^{-3} Pa l s^{-1} are reached.

2.3. Partial pressure analysis

The vacuum system is mainly designed by elastomer seals as the pressure reguirement is moderate. Residual vapours from these seals and also the oils vapours from the rotary pumps contaminate the vacuum system. The residual gas analysis is very clearly confirmed by the presence of these vapours in the spectrum.

In Figure 2 a spectrum of the residual gases measured by a mass spectrometer MX 7304 is shown. By spectra analysis one can see the subsequent contamination by hydrocarbons and other organics.

3. Magnetic Shielding of Turbomolecular Pumps

In our system the turbomolecular pumps are placed in the magnetic field which is leaked from the magnetic structure of the ion source. During the pump operation this field causes an instability in uniform turning of the rotor pump which is

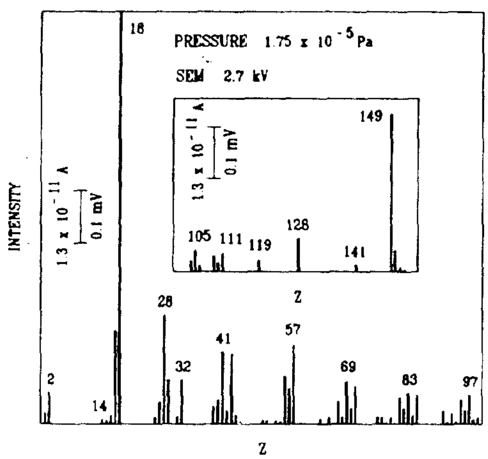

Figure 2. Spectrum of the residual gases from the vacuum system of the DECRIS -14 ion source pumped by the turbomolecular pumps VMN - 500 and the rotary pump BL - 90.

successively increased up to the failure of the pump. Whereas, the failures are caused by the magnetic field we decide to measure levels of this field. Results of these measusuring are reported in Figure 3 (x is the distance from the beam tube axis of the ion source). It is also shown that the given data may be very good fitted by the curve of $y = -3.91126\ x + 825.635$.

The magnetic shielding is made of a 79 NM permaloy about a thickness of 0.2 mm (40 cm wide x 500 cm long). The sheet is twisted to the shape of a 0.3 m dia cylinder. Con-

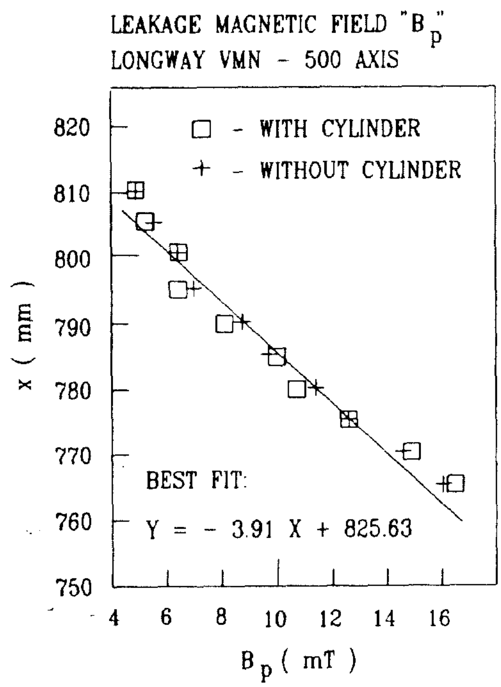

Figure 3. Measured leakage magnetic field "B_p" along the turbomolecular pump VMN - 500 axis.

sequently, the overall thickness of the magnetic shielding is 1 mm.

The satisfactory solution is found by placing the shielded turbomolecular pumps at about 80 cm far from the beam line axis of the ion source.

4. Conclusions

The vacuum system is now virtually completed. All main components are developed and succesfully tested.

5. References

[1] V.B. Kutner and A.A. Efremov, "Problems and perspective directions in development of ECR ion sources", Proceedings of the Workshop Meeting on the DECRIS - 14 Ion Source, Dubna, Russia, P-9-91-263, 29 - 31 January 991, pp. 4 - 6 (Russian).