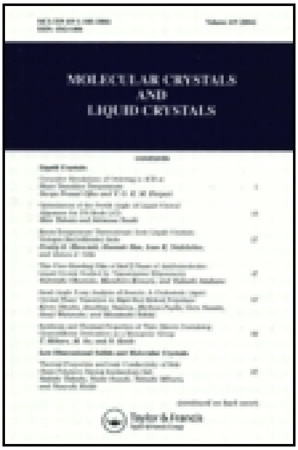

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Autonomous Generator for Technical Oxygen

A. T. Rosca [a], V. Stanciu [b], V. Cimpoiasu [c], R. Scorei [c] & D. Rosca [c]

[a] Research Development and Testing National Institute for Electrical Engineering (ICMET), Craiova, Romania

[b] Research and Development National Institute for Cryogenics and Isotops (ICSI) Rm., Valcea, Romania

[c] University of Craiova, Romania

Version of record first published: 18 Oct 2010

To cite this article: A. T. Rosca, V. Stanciu, V. Cimpoiasu, R. Scorei & D. Rosca (2004): Autonomous Generator for Technical Oxygen, Molecular Crystals and Liquid Crystals, 417:1, 67-73

To link to this article: http://dx.doi.org/10.1080/15421400490481395

Mol. Cryst. Liq. Cryst., Vol. 417, pp. 67/[551]–73/[557], 2004

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400490481395

AUTONOMOUS GENERATOR FOR TECHNICAL OXYGEN

A. T. Rosca
Research Development and Testing National Institute for Electrical Engineering (ICMET) Craiova, 1100, Romania

V. Stanciu
Research and Development National Institute for Cryogenics and Isotops (ICSI) Rm. Valcea, 1000, Romania

V. Cimpoiasu, R. Scorei, and D. Rosca
University of Craiova, 1100, Romania

The Autonomous Generator of Technical Oxygen (AGTO) has been achieved at ICMET Craiova, in cooperation with ICSI Rm. Valcea. It represents a product finalizing a scientific research theme financed by the romanian Ministry of Education and Research.

The AGTO is intended to the brazing, welding and oxygas flame cutting processes, technical fields which can be actually found in all industrial applications. The presented product is based on oxygen generation by using molecular sieves that carry out the selective adsorption of air components.

The selective adsorption of air components, by synthetic zeolites, is possible due to the physical and chemical properties of the gases coming into contact with the adsorber (synthetic zeolite). The main components of air have molecular diameters comparable with the diameter of the molecular sieve pores, the dimensional differences causing the relative selective adsorption at the adsorbing surface of zeolites.

The AGTO performs the air separation for generating oxygen by the selective adsorption of nitrogen, according to Pressure Swing Adsorption (PSA) principle. The AGTO is provided with a programmable automaton, controlling the sequential stages of the selective adsorption: air pressurization of the adsorber at the working pressure; adsorption of nitrogen from air under pressure; pressure equalizing between the two adsorbers; depressurization, period during which most of the adsorbed nitrogen is desorbed; purging (vacuuming), for removing the traces of adsorbed nitrogen; re-pressurization at adsorption pressure.

Address correspondence to A. T. Rosca, Research, Development and Testing National Institute for Electrical Engineering (ICMET) Craiova 1100, Romania. E-mail: adiro@icmet.ro

In the paper are shown the main components figures and the values obtained for oxygen purity using several initial pressure and air humidity.

CONSTRUCTIVE DATA

The stages of the selective adsorption process have allowed the modular design of AGTO, which has modules for: compressed air and gas filtration process; compressed air drying module with molecular sieves; selective adsorption module with zeolitical molecular sieves; oxygen storing module; automatic control module for the stages of the selective adsorption process.

1. Pneumatical and Mechanical Components

For making oxygen by selective adsorption of nitrogen, according to PSA principle, the vessel of the compressed air drying module (A_1) is filled with X-type molecular sieves, and the vessels of the adsorption modules (A_2 and A_3) are filled with A-type zeolite molecular sieves [1,2]. The compressed air drying module with molecular sieves (A_1) is provided with a flowmeter for air, which indicates the flow rate of compressed air of generator supplying, and the oxygen storage module (V_1) is provided with a flowmeter for oxygen, which indicates the oxygen flow rate produced by the autonomous generator (Figure 1).

FIGURE 1 Autonomous generator for technical Oxygen.

Each of the vessels A_1, A_2, A_3 and V_1 is provided with a pressure gauge, and for emphasizing the pressure losses during the operation stages of the generator. The emphasizing of the working pressure during the vacuuming stages is done by means of a pressure-vacuum gauge. The purging (vacuuming) for eliminating the traces of adsorbed nitrogen is done by means of a vacuum pump with a supply flow rate of $15\,Nm^3/h$ and the limit pressure of $1.5 \cdot 10^{-2}$ mbar [3]. The vessels have been designed and manufactured according to **ISCIR** norms (State Inspection for Controlling the Reservoirs, Pressure Vessels and Hoisting Units).

The pneumatic circuits which supply the vessel of each module are provided with systems for filtering the processed gas, having selective filtration of 5 µm; 0.3 µm; 0.01 µm.

The compressed air supplying circuit is provided with a ratio separator, which is fitted with porous sieves too, assuring a primary filtration sharpness of 15–20 µm.

The dimensions of the pipes and joints of each module have been optimized for minimal pressure losses caused by the friction forces, the local resistance respectively.

The gases processed in different stages of the selective adsorption process is done by means of 10 electropneumatic valves with controlled membrane and directional valve, Normally Open 2/2. To avoid the explosive hazard which could result from the mixture between oxygen and the lubricant necessary for electropneumatic equipment operation, the selected electric valves are of NO OIL type [3].

The cycle sequences of the modules for selective adsorption with zeolite molecular sieves (A_2 and A_3) can be carried out in automatic cycle, by coupling simultaneously or successively the 10 electropneumatic valves, according to those presented in Table 1.

2. Electronic Components

In the main, the electronic components of the prototype (carried out in cooperation with ICSI Rm. Valcea) consist in electric and automation elements composed of (Figure 2): electropneumatic valve control unit and control and signaling module respectively.

a) The **electropneumatic valve control unit** is a programmable automaton which controls the sequences of AGTO. The setting of the time values for the sequences, also the electropneumatic valves which are actuated within a sequence, are made by program, or from the console of the graphical indicator module.

The control of the electropneumatic valves is done by means of an actuating block containing intermediate relays. Because this product is an experimental one, the possibility to actuate manually the electropneumatic

TABLE 1 Automatic Cycle Sequences

EPVi	Vacuuming $A_2 + A_3$ 120 ÷ 180 sec	Pressuriz. A_2 Regener. A_3 20 ÷ 40 sec	Adsorp. A_2 Regener. A_3 60 ÷ 180 sec	Equaliz. $A_2 \rightarrow A_3$ 20 ÷ 30 sec	Pressuriz. A_2 Regener. A_3 20 ÷ 40 sec	Adsorp. A_2 Regener. A_3 60 ÷ 180 sec	Equaliz. $A_3 \rightarrow A_2$ 20 ÷ 30 sec	Pressuriz. A_2 Regener. A_3 20 ÷ 40 sec
E1	C	O	O	C	C	C	C	O
E2	C	C	C	C	O	O	C	C
E3	C	C	O	C	C	C	C	C
E4	C	C	C	C	C	O	C	C
E5	O	C	C	C	O	O	C	C
E6	O	O	O	C	C	C	C	O
E7	C	C	C	O	C	C	O	C
E8	C	C	C	O	C	C	O	C
E9	C	C	C	C	C	C	C	C
E10	O	C	C	C	C	C	C	C

Note: EPVi – Electropneumatic valve "i"; C – closed; O – open; Adsorp. – adsorption; Pressuriz. – pressurization; Regener. – regeneration; Equaliz. – equalization.

FIGURE 2 Programable automation.

valves, from the button, is also introduced; therefore, there are two operating duties (manual or automatic).

The elaboration of the automation program is done on the basis of an automation platform, which contains working facilities: time constant setting; operation mode selection; starting and stopping sequence; functional messages etc.

The process control is done by control loops, existing 3 integrated functions: PID (Proportional-Integrative-Derivative), PWM (Pulse Width Modulation) and SERVO (discrete control of valves). The programmable automaton is fitted with main display unit, which gathers all the data necessary for the control, diagnosis, maintenance of this one and its modules, also of the man-machine interface functions (Figure 2) [3].

b) The **control and signaling module** contains all the indicating and control devices. On the frontal panel of this module containing the electrical and automation parts, the following elements are placed: display unit and programmable automaton keyboard; button for selecting the control (manual/automatic) of the electropneumatic valves; electropneumatic valve control button; light indicators for electropneumatic valve condition.

The **display unit** is a terminal with two-line fluorescent alphanumeric display, having 20 characters, able to communicate, in a serial way, with the programmable automaton or with a PC. The keys can be used for changing the variables, controlling the device or navigating in some application, also for printing the alarm messages or data pages. The function keys are of two types: static and dynamic. The static function keys are defined for the entire application and can be used for accessing the pages, setting the bits of the programmable automaton memory etc. The dynamic function keys are associated to one page, and their function can be changed from one page to another. To each of these keys a label is assigned (bitmap image).

On the frontal panel of the display unit there are disposed: a LED for communication monitoring, a LED for indicating the keyboard activity, fluorescent display, "function" keys with indicating LEDs and the corresponding re-usable labels, working keys with indicating LEDs, numerical keys.

EXPERIMENTAL RESULTS

The prototype certification has been based on checking the constructive-functional characteristics (pressure, compressed air supply flow rate, respectively) and the operating abilities (air humidity at supplying; air humidity after drying; oxygen concentration at the generator output), the most important values being:

- processed gas flow rate (compressed air) 0.5 – 0.8 Nm^3/h;
- working/supply pressure of the processed gas (compressed air) 4 – 10 bar;
- air humidity after drying adsorber 0.24 – 0.4 g H_2O/m^3;
- oxygen flow rate at PSA adsorber output 0.2 – 0.44 Nm^3/h.

The oxygen concentration checked at PSA adsorber output has been performed by Gas-Chromatograph Hewlett – Packard 7620 A. The representative O_2 concentration values obtained in AGTO for compressed air supply pressure of 4 and 6 bar, are given in Table 2.

TABLE 2 AGTO Representative O_2 Concentration

SN	Compressed air supply pressure [bar]	Air humidity at supplying [g H_2O/m^3]	Air humidity after drying [g H_2O/m^3]	Air flow rate at supplying [l/h]	O_2 concentration at output [%]	O_2 flow rate at output [l/h]	O_2 pressure in V_1 vessel [bar]
1	4	11.98	0.28	500	72.0	246.5	3.40
			0.31	600	72.0	300.0	3.50
			0.33	700	70.5	350.0	3.55
			0.34	800	68.0	420.0	3.60
			0.30	500	80.2	200.0	3.55
2	6	11.98	0.32	600	78.7	250.3	3.60
			0.34	700	76.8	309.7	3.70
			0.36	800	74.5	367.7	3.75

As a result of the experiments, it was recorded that during the PSA-type selective adsorption, the zeolite molecular sieve is consumable, so it must be replaced, because it influences the quality of the oxygen making. For establishing the life-time of the molecular sieve, another experimental researches are necessary.

REFERENCES

[1] Sokolov, V. A. (1965). Molecular sieves. Bucharest Technical Publishing House.

[2] Cruceanu, M. (1986). Zeolite molecular sieves. Bucharest Scientific and Encyclopedic Publishing House.

[3] Rosca, A. T. (project manager). Autonomous generator of technical oxygen for industrial application. Research project A59/2002, financed by the romanian Ministry of Education and Research.