UDC 621.3.049.77(045)

[1]V. M. Sineglazov,
[2]V. N. Fedosenko,
[3]N. S. Voropaev

COMPUTER-AIDED DESIGN SYSTEM OF CLEANROOM ELEMENTS

Aviation Computer-Integrated Complexes Department, National Aviation University, Kiev, Ukraine
E-mails: [1]svm@nau.edu.ua, [2]fedos@tp.kiev.ua, [3]voropaevnikolay@gmail.com

Abstract. *The problem of designing cleanroom, in particular their system components. The classification of the main structural elements: walls, ceilings, floors, windows, doors, lighting, coatings. The structure of computer-aided design system components.*

Keywords: cleanrooms; computer-aided design system; components.

Introduction

Space requirements, which must be ensured that the necessary technological processes of microelectronics, were and are very tough. Top quality products, constant struggle to raise the productivity require precise control and coordination between the process equipment, engineering and work organization, and all this is based on the strict observance of the parameters of the surrounding space, in turn, is based on modern technology cleanroom.

Manufacturers microelectronic devices are widely used clean rooms where the air are supported in a certain predetermined range size and number per cubic meter of particles such as dust, microbes , aerosol particles and chemical vapors. In such areas it is necessary to minimize the introduction, generation and storage of such particles indoors. If necessary, they can also be controlled by other parameters such as humidity, pressure and temperature. Modern technological operations are conducted almost at the molecular level, but from the standpoint of physics process work product depends on the purity of the material, as measured by levels. lower than one impurity atom per trillion (10^{12}) atoms of the main substance.

To properly design, construct and operate clean rooms, it is necessary to know the relationship between the planning, design, materials, operators , etc., and "purity class". Class clean room depends on the tasks to be solved in it. More sensitive to pollution produced products or process, the higher should be the level of cleanliness in the room. Higher purity requires certain design concepts and the best materials for interior surfaces of a room, as well as increased frequency of cleaning, better quality clothes, the best changing rooms, etc.

Over the last 20 years, class clean room based on the measurement of non-living in nature (non-native organisms) aerosol particle size > 0.5 mm or > 5 mm. U.S. Federal Standard 209E considering five particle sizes > 0.1 microns > 0.2 microns > 0.3 microns > 0.5 mm and > 5.0 mm. Also contemplated ultrasmall (ultrafine) particles are defined as having a size of <0.02 microns and larger, or particulates having a size of > 5 micron. This method of classification is also used by international standards CEN and ISO. Example cleanroom classification according to ISO 14644-1 priveden in Table 1.

Table 1

Cleanroom classification standard ISO 14644-1

ISO category	The maximum allowable concentration of particles (particles / m 3 of air), whose size is equal to or higher than indicated in the table					
	> 0,1 µm	> 0,2 µm	> 0,3 µm	> 0,5 µm	> 1 µm	> 5 µm
ISO 1	10	2	–	–	–	–
ISO 2	100	24	10	4	–	–
ISO 3	1000	237	102	35	8	–
ISO 4	$10 \cdot 10^3$	2370	1020	352	83	–
ISO 5	$10 \cdot 10^4$	23700	10200	3520	832	29
ISO 6	$10 \cdot 10^5$	$23{,}7 \cdot 10^4$	$10{,}2 \cdot 10^4$	35200	8320	293
ISO 7	–	–	–	$35{,}2 \cdot 10^4$	83200	2930
ISO 8	–	–	–	$35{,}2 \cdot 10^5$	$83{,}2 \cdot 10^4$	$29{,}3 \cdot 10^3$
ISO 9	–	–	–	$35{,}2 \cdot 10^6$	$83{,}2 \cdot 10^5$	$29{,}3 \cdot 10^4$

Structure Cleanroom

Block diagram of cleanroom shown in Fig. 1 and includes the following elements: a system of structural elements, ventilation and air-conditioning control system.

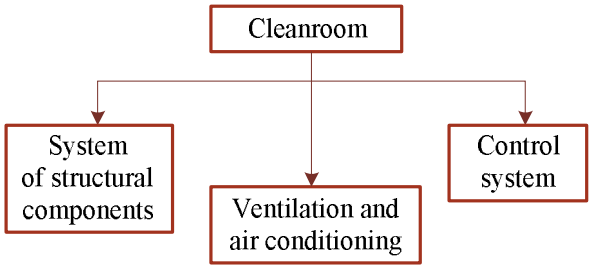

Fig.1. Block diagram of cleanroom

The system of structural elements consists of: subsystem ceilings, subsystem interior and exterior walls, floor subsystem, subsystem doors, windows subsystem, subsystem lighting.

Ventilation and air conditioning system includes: air handling subsystem (air filtration, air conditioning, humidification and dehumidification), ductwork, ceiling diffusers and grilles fence.

The control system includes: the control device climatic parameters inside the cleanroom (temperature, humidity), subsystem maintain a positive pressure inside the cleanroom, device monitoring and control to maintain the purity of air, access control devices inside the cleanroom. Block diagrams of these systems are shown in Figs 2 and 3, 4 respectively.

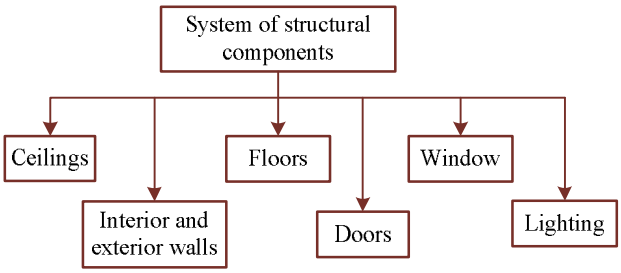

Fig. 2. Block diagram of the system of structural elements

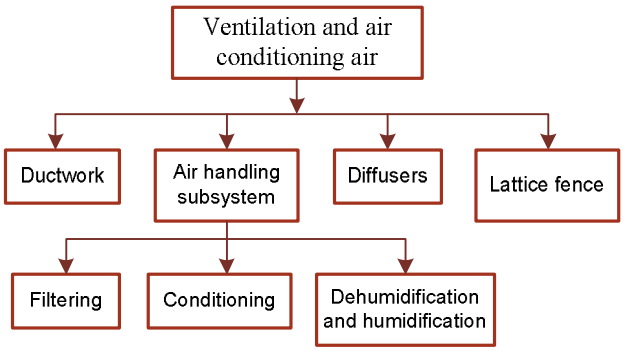

Fig. 3. Block diagram of the ventilation system and air conditioning

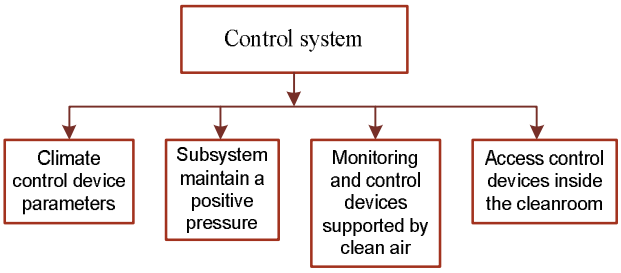

Fig. 4. Block diagram of the control system

Statement of the problem .In this paper, the task of designing a system of structural elements cleanroom based on the type of the process, providing the necessary purity class specified geometric dimensions premises. The task of designing structural elements include:

– choice of types of structural elements according to the following classification table;

– determine the number of structural elements and their sizes.

The main criteria for the selection of structural materials and surfaces for cleanroom use: functionality, durability, ability to clean and repairable.

Classification of types of ceilings, interior and exterior walls, floors are shown in Table 2.

Classification of lighting systems may be presented in form.

1. Hanging lamps for light metal ceilings and aluminum framed glazing

2. Recessed fluorescent lamps for light metal ceilings.

3. Diode lights.

4. System UV – irradiation cleanroom, which may consist of:

– blocks UV – irradiators cleanroom;

– blocks UV – irradiators access system in the clean room.

Table 2

Classification of types of ceilings, interior and exterior walls, floors

no	Typeceilings, floors, wall partitions	Features	Manufacturer
1	Metalceilingspanels	Dual-layer panel: the lower layer facing into the room, made of galvanized sheet steel, powder-coated or stainless steel sheet, the upper layer – plasterboard.	AMF (Germany) Ceiling Group (USA) Ecophon (Sweden) Isofon (China) Bard (Russia)
2	Plasticceilingspanels	Panels monolayer of high pressure laminate (HPL).	AM-plast (Russia) Service-Complect (Russia) KlimaOprema (Croatia)
3	Ceilingspanelsof "sandwich"	Solid panel type “sandwich” with a shell of aluminum and filled with polystyrene/epoxy composition.	Pharmstroy RK (Russia) ClimateSpecProject-mounting (Russia) Master of Technology (Ukraine)

Ending of the table 2

no	Typeceilings, floors, wall partitions	Features	Manufacturer
4	Tilefloors	Production tile coating is carried out by compaction under high pressure PVC homogeneous mass with graphite inclusions on a limited area of tiles. This ensures homogeneity of the whole thickness, which prevents its rapid galling even in harsh operating conditions. Such a coating is conductive.	TSK engineering (Russia) ARMSTROYComfort (Russia) Laminar Systems (Russia)
5	Polymerflooring	- High impact strength and elasticity; - The highest resistance to abrasion; - Withstands temperatures ranging from -30 ° C to +90 ° C; - High chemical resistance; - Can be performed in an antistatic version; - Handles heavy mechanical loads.	ARMSTROYComfort (Russia) KlimaOprema (Croatia) AM-plast (Russia)
6	Concretefloors	May take considerable mechanical load. Sensitive to temperature and humidity.	BETONOFF (Russia) Quangong Machinery (China)
7	Otherfloors	Heterogeneous anti-static floor: - Used dense fiberglass; - Durable, made of pure PVC without fillers wear layer thickness of 0.7 mm and polyurethane reinforcement surface guaranteed to provide a great view of sex and long-term protection from damage.	PHARMSTROY RK (Russia) Isofon (China) Albes (Russia)
		Raised floor: - For rooms with laminar flow; - With ventilation grilles; - PVC-coated and adjustable fittings (racks, stringers, etc.)	
8	Gypsummetal wall partitions	Made of galvanized, powder coated, or stainless steel sheets	IBC Systems (Russia) Pharm-Engineering (Russia) Ingermax (Russia)
9	plastic wall partitions	Made of high pressure laminate (HPL)	IBC Systems (Russia) Pharm-Engineering (Russia) KlimaOprema (Croatia)
10	Three-layer type of “sandwich” wall partitions	Two outer layers - galvanized steel, powder painted, or non-rusting steel. Filler – hard rock wool	PHARMSTROY RK (Russia) ClimateSpecProject-mounting (Russia) Laminar Systems (Russia)

Condition cleanroom surfaces can have a significant effect on the purity of products produced in it. Therefore, materials used in the construction of clean rooms must be chosen taking into account that they will not generate particles or other contaminants which could contaminate the product. To achieve these goals, the materials must:

– easy to clean and, where necessary, be resistant to water, detergents and disinfectants;

– be strong, and do not emit particles to be chemically inert;

– if necessary, have antistatic properties.

Fig. 5 are presented in hierarchical order all the requirements that must be considered in the selection of materials for use in clean rooms [1].

The materials which do not generate particles, and therefore are widely used in the construction of clean rooms are [2]:

– stainless steel;

– sheet metal, powder coated (or anodized aluminum sheet);

– sealed with concrete surface;

– plastic sheets joined by hot welding;

– coating of polymer non-shrink materials;

– keramicheskie materialy;

– glass.

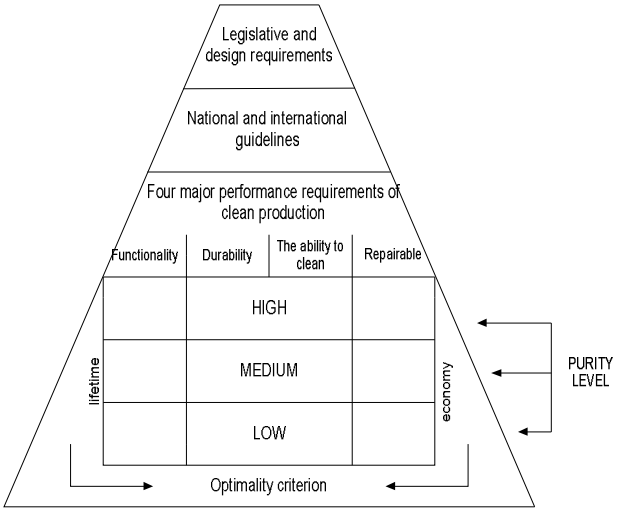

Fig. 5. Hierarchy of requirements for construction materials used in clean rooms

Development of computer-aided design system of structural elements.

The task of designing cleanroom considerably simplified if its solution used computer-aided design. Structure of computer-aided design system of structural elements is presented in Fig. 6.

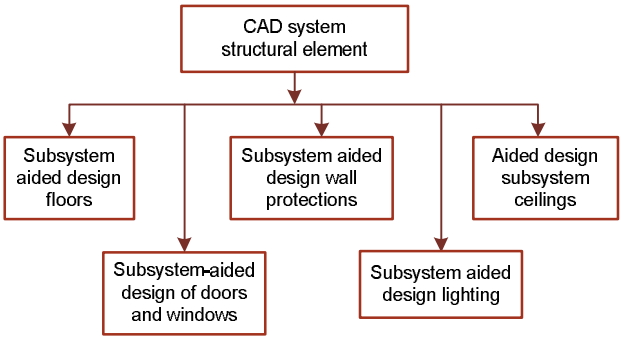

Fig. 6. Block diagram of the CAD system of structural elements

Block diagram of algorithmic support computer-aided design can be represented as (Fig. 7).

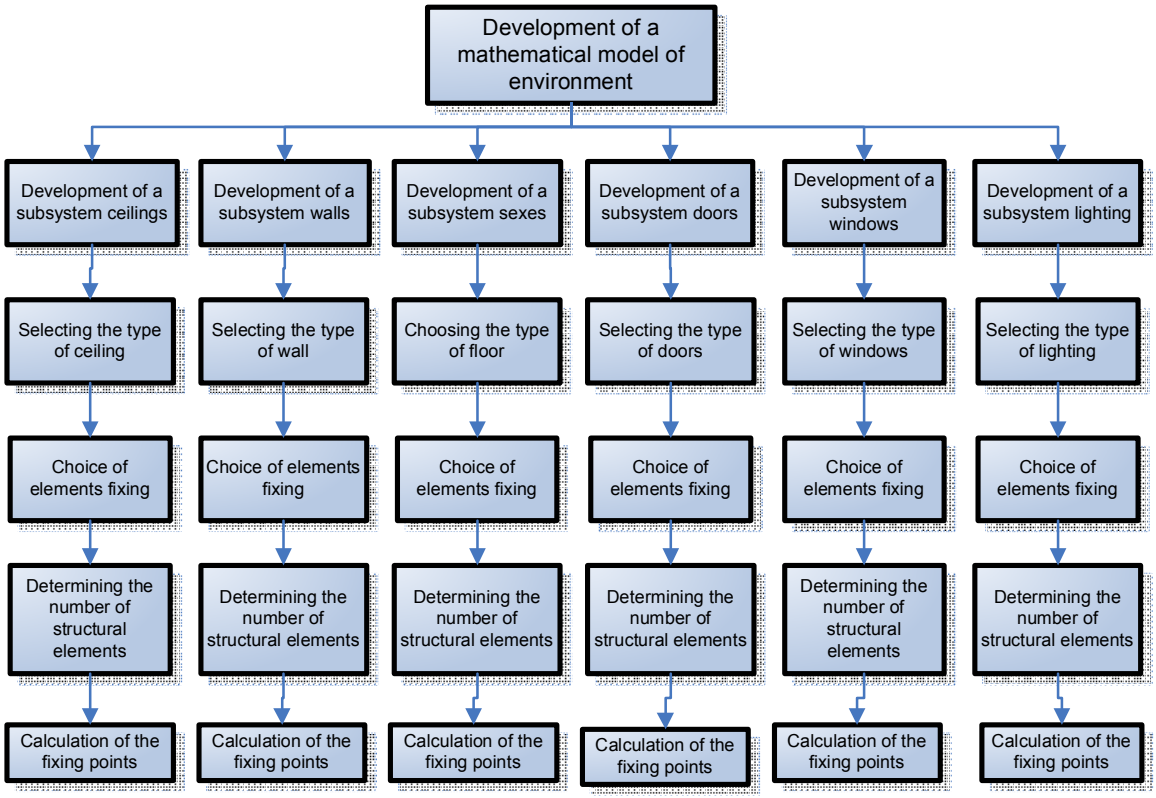

Fig. 7. Block diagram of algorithmic support computer-aided design

Selecting the type of the component on the basis of solving the problem of multicriteria optimization according to certain criteria above [4]–[7].

Conclusions

The necessity of using computer-aided design in the design of cleanrooms. It is shown that the fundamental source of data are: the type of process cleanliness class, with various facilities. It is shown that the main criteria for the design of cleanrooms are: functionality, durability, ability to clean and repairable.

References

[1] White, W. “Cleanroom Design.” Moscow. 2004. pp. 216–224. (in Russian).

[2] GOST 50766–95. "Cleanrooms. Classification. Methods appraisals. Basic requirements." 1996. 33 p.(in Russian).

[3] Walling cleanroom. "Miass LLC Plant Miassky medical equip-ment" and ZAO "Aseptic medical system." 48 p. (in Russian).

[4] Beyko, I. V.; Bagel, B. N.; Zin'ko, P. N. "Methods and algorithms for solving optimization problems." Kyiv, *Vyshcha shkola*. 1983. 511 p. (in Russian).

[5]. Borisov, V. I.; Vinogradskaya, T. M. "An algorithm for determination of the Pareto." *Proceedings of the 1st All-Union Conference on Operations Research.* Minsk. Institute of Mathematics. 1975. (in Russian).

[6] Venec, V. I. "Continuous algorithms for solving convex constrained minimization problems using the projection operation on the admissible set." *Automation and Remote Control*. 1985. no. 7. pp. 73–78. (in Russian).

[7] Volkovich, V. L. "Multicriteria problems and their solutions." *Cybernetics and Computer Science*. 1969. MY. 1. pp. 44–52. (in Russian).

Received 02 December 2013.

Sineglazov Viktor Mikhaylovich. Doctor of Engineering. Professor.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine
Education: Kyiv Polytechnic Institute, Kyiv, Ukraine (1973).
Research area: Air Navigation, Air Traffic Control, Identification of Complex Systems, Wind/Solar power plant.
Publications: 452.
E-mail: svm@nau.edu.ua

Fedosenko Viktor Nikolaevich. Postgraduate student.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine.
Education: Kyiv Polytechnic Institute, Kyiv, Ukraine (1984).
Research interests: computer-aided design.
Publications: 3.
E-mail: fedos@tp.kiev.ua.

Voropaev Nikolay Sergeevich. Student.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine.
Research interests: computer-aided design.
Publications: 0.
E-mail: voropaevnikolay@gmail.com.

В. М. Синєглазов, В. М. Федосенко, М. С. Воропаєв. Система автоматизованого проектування системи конструктивних елементів чистих приміщень

Розглянуто проблему проектування чистих приміщень, зокрема системи їх конструктивних елементів. Розроблено класифікацію основних конструктивних елементів: стіни, стеля, підлога, вікна, двері, освітлення, покриття. Запропоновано структуру системи автоматизованого проектування системи конструктивних елементів.

Ключові слова: чисті приміщення; система автоматизованого проектування; система конструктивних елементів.

Синєглазов Віктор Михайлович. Доктор технічних наук. Професор.
Кафедра авіаційних комп'ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Освіта: Київський політехнічний інститут, Київ, Україна (1973).
Напрям наукової діяльності: аеронавігація, управління повітряним рухом, ідентифікація складних систем, вітроенергетичні установки.
Кількість публікацій: 452.
E-mail: svm@nau.edu.ua

Федосенко Віктор Миколайович. Аспірант.
Кафедра комп'ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Освіта: Київський політехнічний інститут, Київ, Україна (1984).
Напрям наукової діяльності: системи автоматизованого проектування.
Кількість публікацій: 3.

E-mail: fedos@tp.kiev.ua.
Воропаєв Микола Сергійович. Студент.
Кафедра комп'ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Напрям наукової діяльності: системи автоматизованого проектування.
Кількість публікацій: 0.
E-mail: voropaevnikolay@gmail.com.

В. М. Синеглазов, В. Н. Федосенко, Н. С. Воропаев. Система автоматизированного проектирования системы конструктивных элементов чистых помещений

Рассмотрена проблема проектирования чистых помещений, в частности системы их конструктивных элементов. Разработана классификация основных конструктивных элементов: стены, потолки, пол, окна, двери, освещение, покрытия. Предложена структура системы автоматизированного проектирования системы конструктивных элементов.
Ключевые слова: чистое помещение; система автоматизированного проектирования; система конструктивных элементов.

Синеглазов Виктор Михайлович. Доктор технических наук. Профессор.
Кафедра авиационных компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Образование: Киевский политехнический институт, Киев, Украина (1973).
Направление научной деятельности: аэронавигация, управление воздушным движением, идентификация сложных систем, ветроэнергетические установки.
Количество публикаций: 452.
E-mail: svm@nau.edu.ua

Федосенко Виктор Николаевич. Аспирант.
Кафедра компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Образование: Киевский политехнический институт, Киев, Украина (1984).
Направление научной деятельности: системы автоматизированного проектирования.
Количество публикаций: 3.
E-mail: fedos@tp.kiev.ua.

Воропаев Николай Сергеевич. Студент.
Кафедра компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Направление научной деятельности: системы автоматизированного проектирования.
Количество публикаций: 0.
E-mail: voropaevnikolay@gmail.com.