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INFRASTRUCTURE FOR MULTI-FLOOR VIRTUAL ENTERPRISES SYSTEM

8.1 INTRODUCTION

Contemporary urbanization is characterized by the growth of population density of large cities and the increase in the share of high-rise and multi-floor buildings, including manufacturing in the total volume of construction. This is due to the preservation of areas and land suitable for agricultural use, and to reduce the length of communications in urban areas [8, 17]. The multi-floor manufacturing plants in an urban environment are associated with the creation of innovative products for the metropolis, the emergence of new information and production and management technologies, quality change of labor resources, improving transportation communications and logistics, more efficient use of natural resources [13, 14]. Of particular note is the emergence of new forms of organization of enterprises – virtual enterprises, as well as environmentally friendly production, meeting the sanitary standards, including, residential buildings [2, 14].

The concept of virtual enterprises in various scientific work is treated differently [2, 8, 9, 10, 11, 15]. We will use the concept of a virtual enterprise, proposed by H.A. Wüthrich and A.F. Philipp. "Virtual enterprise is a temporary form of voluntary cooperation of several normally independent partners (enterprises, institutes, and individuals), ensuring optimized manufacturing systems benefits great benefits to customers'' [15]. Should be supplemented that the vast majority of virtual enterprises – small and medium enterprises (SMEs) [10]. The ability to change the configuration of cooperated enterprises depending on market conditions allows flexible production aimed at efficient satisfaction of the needs of a particular customer in the product or service. In the work of the staff of virtual enterprises using principles of co-operation, self-organization, self-optimization, self-configuration, self-control [13] and self-education, own creativity are used. Virtual enterprise can be connected to production: machining, assembly, machining and assembly: transport, communications, financial, insurance, trade, socio-economic and other. They may also apply to individual sectors or groups of industry: 1. Renewable sources of energy. 2. Industrials: Capital Goods, Commercial & Professional Services, Transportation. 3. Consumer Discretionary: Components for Automobiles, Consumer Durables & Apparel. 4. Consumer Staples: Food, Household & Personal Products. 5. Health Care Equipment & Services. 6. Financials: Banks, Insurance. 7. Information Technology: Software & Services, Technology Hardware & Equipment, Semiconductors & Semiconductor Equipment. 8. Telecommunication Services. 9. Utilities [6].

The infrastructure of the enterprise, including virtual, - a set of interrelated components and systems necessary for the functioning of its economy and not directly involved in the creation of value of goods [12]. The infrastructure of the enterprise and its functions can be divided into three blocks: 1. Infrastructure for resource provision of the enterprise personnel, knowledge, information, innovation, capital, energy and materials. 2. Infrastructure for manufacturing maintenance: support manufacturing and metrology, transport, insurance, trade, socio-economic and other services [18]. 3. Critical infrastructure - infrastructure which is based on the government's assets functioning of enterprises in a certain sector of the economy [21].

Of greatest interest is infrastructure maintenance of manufacturing system of multi-floor virtual enterprises. This is due to the fact that there is no recommendation on placement of the main and supporting virtual enterprises in high-rise production. In addition, interest for the functioning of such enterprises research issues associated with:

- negotiate the bandwidth of vertical and horizontal transportation system performance of multi-floor virtual enterprises;
- analysis of the ownership forms of fixed assets of the main and supporting virtual enterprises.

The purpose of this paper is to develop recommendations for the formation of infrastructure for virtual multi-floor manufacturing system and assembly enterprises taking into account specificity of the organization of production and transport, the ownership forms of main manufacturing and maintenance production.

8.2 INFRASTRUCTURE OF SYSTEM OF MULTI-FLOOR VIRTUAL ENTERPRISES

Multi-floor virtual enterprises are divided into three types: machining, assembly, machining and assembly. The term of the manufacturing enterprise refers to the enterprise using a wide range of technological equipment, changing its form and physical and mechanical properties of the object of labor, for example, technological equipment for cutting or the implementation of additive technologies.

In multi-floor virtual enterprises can be used such kinds of manufacturing as piece, repetitive, variant and serial, which are based on the following principles of production: workshop, production bay, flexible system in accordance with the classification proposed in the work [18]. In systems of multi-floor virtual enterprises you can use the distributed principle of organization of production, the essence of which lies in the organization of production through outsourcing [20]. The system of multi-floor virtual enterprises with distributed principle of production organization is a group of multi-floor buildings with virtual enterprises located arbitrarily in an urban environment, along with residential, administrative, public and other buildings, and interconnected industries and to service their businesses through the Internet and vehicles. The infrastructure for the multi-floor virtual enterprises depends on the form of organization of production. The following forms of production system for the multi-floor virtual enterprises system are used: linear form of organization of production; cell form of organization of production; technological form of organization of production; mixed solutions [1]. The

choice of the type of organization of production depends on plan for use in multi-floor virtual enterprises form and principle of production.

A linear form of organization of production on each floor of the building can be used for single, repetitive and variable types of production using the principles of organization of production – a workshop and production bay. In this case, the linear form of production organization used in a multi-floor mixed group of virtual enterprises when the same building to accommodate manufacturing and assembly facility. The disadvantage of this form and specified principles of organization of production is not high performance and flexibility, which makes it difficult to promptly meet the needs of the client. A linear form of organization of production is used in flexible production lines in multi-floor virtual enterprises. In this case, the line sections with buffer storage devices are located on different floors of the building, to ensure high performance and production flexibility. However, the presence of multi-floor production lines significantly increases their maintenance freight elevators and combination of form and principle (flexible system) is applied in virtual manufacturing enterprises.

The cell form of organization of production is most often used in multi-floor virtual assembly manufacturing, machining and assembly manufacturing. In this case, on the floors in several rooms, located autonomous assembly or machining cells. This form of organization of production allows providing high performance and flexibility of production. The technological form of organization of production is applied in multi-floor virtual manufacturing enterprises. In this case, each floor of the main production the technological equipment placed in the same group, for example, the lathes, which allows the manufacture of product groups with different constructive, but the overall technological features [1]. This form of organization of production allows reducing the auxiliary time when performing various technological operations in terms of mass production.

The possibility of placing technological equipment in multi-floor virtual enterprises associated with a reduction in the weight and dimensions of process equipment due to the miniaturization of products, the use of additive technologies and technological equipment of the frame construction [3, 13, 18]. It is important that the process equipment supplied to the customer only unassembled assembled on site in the virtual enterprise [3]. The infrastructure for resource provision and maintenance of multi-floor manufacturing system of virtual enterprises is divided into production and non-production infrastructure, which respectively operate main production and personnel.

The production infrastructure consists of the following virtual enterprises: transaction, consulting, design, project-technological, logistic, transport, maintenance of main and auxiliary production, tooling, metrology, and maintenance of buildings. Of these enterprises, the purpose and function of which are well known, it is necessary to allocate transaction enterprise. In fact, the transaction enterprises is the “heart” of the multi-floor virtual enterprises as engaged in search of clients, potential suppliers of materials and components, coordination of the prices of products and timing of its production, organization of production networks, concluding contracts and monitoring their implementation, legal protection of the client.

a)	b)	c)
23, 24, 25	23, 24, 25	23, 24, 25
21, 22	21, 22	21, 22
18, 19, 20	18, 19, 20	18, 19, 20
16, 17	16, 17	16, 17
15	15	15
14	14	14
13	14	13
13	13	13
11	12	11
11	4, 12	11
11	12	11
10	12	7, 8, 9, 10
10	4, 12	7, 8, 9, 10
10	12	7, 8, 9, 10
9	12	7, 8, 9, 10
9	4,12	7, 8, 9, 10
9	12	7, 8, 9, 10
8	12	7, 8, 9, 10
7	4, 12	7, 8, 9, 10
7	12	6
6	12	5
5	4, 12	5
5	12	12
5	12	4, 12
4	4, 12	4, 12
3	3	3
3	3	3
1, 2, 26	1, 2, 26	1, 2, 26

Fig. 8.1 Diagrams of multi-floor virtual enterprises:
a) Machining b) Assembly c) Assembly and machining enterprises

Legend:
1 – Parking enterprise.
2 – Enterprise of building maintenance.
3 – Temporary storage enterprise (arrivals/issuing).
4 – Paint enterprise.
5 – Grinding machines enterprises.
6 – Heat treatment enterprise.
7 – Drills enterprises.
8 – Shapers enterprise.
9 – Milling machines enterprises.
10 – Lathes enterprises.
11 - Enterprises for additive manufacturing.
12 – Assembly enterprise.
13 – Tool enterprise.
14 – Metrological enterprise.
15 – Enterprise for maintenance of main and auxiliary production.
16 – Planning and design enterprise.
17 – Technology enterprise.
18 – Transnational enterprise.
19 – Consulting enterprise.
20 – Logistics and transport enterprise.
21 – Grocery stores.
22 – Pharmacies.
23 – Recreation and fitness enterprise.
24 – Hairdressers enterprise.
25 – Catering enterprise.
26 – Commercial building maintenance.
Source: own elaboration

The non-production infrastructure aimed at meeting the social needs of staff, which cannot be met through the Internet. For example, banking services or tour services available via the Internet and therefore to provide a multi-story in virtual enterprises, such services are not economically viable. For example, banking services or tour services available via the Internet and therefore to provide in the multi-floor virtual enter-

prises, such services are not economically viable. Of social the range of services we can offer you the following virtual enterprise: catering, recreation and fitness, hairdressers, commercial building maintenance, grocery stores, pharmacies, parking, etc.

In Fig. 8.1 shows a possible distribution infrastructure multi-floor virtual enterprise on the floors of the building depending on the type and form of organization of main production (a – exemplary layout of technological organization of production; b – diagrams of enterprises allocation in item work cells with the course of technological process; c – diagram of workplace allocation in production lines).

The ratio of occupied floors, the main production and maintenance of its infrastructure should ensure maximum profitability of the system multi-floor virtual enterprises. Therefore, the main production it is advisable to not less than half of all floors of the building. The ratio of the occupied floors of the main production and service with consideration of nomenclature, types, kinds, principles and forms of organization of main production may trade line based on the analysis of the refraction of the profitability of the entire system.

Functioning of the system of multi-floor virtual enterprises depends on the horizontal and vertical transport. If demand for transportation between buildings of the system of virtual enterprises (horizontal transport) can be met by increasing the number of vehicles used, transport the vertical transport of materials, components, finished products, instruments and process equipment, personnel, etc. is limited to throughput of freight and passenger elevators of the buildings. A relatively stable number of staff for the multi-floor virtual enterprises allows predicting and providing for efficient movement of personnel elevators of the building. More complex task with the organization of operation of freight elevators are buildings. This is due to the fluctuations in the demand for some goods in the market that affect the load on the main production. It is therefore important to harmonize the bandwidth of the vertical transport and the performance of main and auxiliary production of multi-floor virtual enterprises with distributed infrastructure.

8.3 HARMONIZATION THROUGHPUT OF VERTICAL TRANSPORTATION AND THE PERFORMANCE OF PRIMARY AND SECONDARY PRODUCTION

Criteria for matching the bandwidth of the vertical transport and the performance of main and auxiliary production of multi-floor virtual enterprises are defined under the following assumptions: 1. Weight (volume) performance of virtual enterprises of main production on every floor the same. 2. Each freight elevator has the same load (volume capacity). Based on the above assumptions conditions weight (volume) performance of the main production taking into account the throughput of freight elevators are defined:

$$G_{W(V)} \leq \frac{\varepsilon\left(Q_{W(V)} - \lambda L_{W(V)}\right)}{\left(T_{C.B} + T_{C.A}\right)} \tag{8.1}$$

where:

G_W – the weight performance of the virtual enterprises of main production every floor, N/h;

G_V – the volume performance of the virtual enterprises of main production on every floor, m³/h;
Q_W – the rated load of freight elevator, N;
Q_V – the nominal volume capacity of the freight elevator, m³;
L_W – the weight of the trolley, N;
L_V – the volume, occupied the trolley, m³;
$T_{C.B}$, $T_{C.A}$ – accordingly, the cycle time of operation of freight elevators during maintenance of the main and auxiliary production, h;
ε – the number of the freight elevators, pcs;
λ – the number of the trolleys in the freight elevator, pcs.

Time of cycles of the freight elevators work at consistently (shuttle) maintenance of the main and auxiliary production is determined with the following expression:

$$T_{C.B} = 2k_C h \cdot F_B^2 / 3600 v\varepsilon \quad (8.2)$$

$$T_{C.A} = 2k_C h \cdot F_A^2 / 3600 v\varepsilon \quad (8.3)$$

where:
k_C – the coefficient of losses of time cycle of a work of the freight elevators, the values of that are in limits k_C = 1,05 - 1,6 (with the increase of floors number of assembly manufacturing a value of the coefficient aspire to unit);
F_B, F_A – accordingly, the number of floors of the building, , which contains the main and auxiliary production;
h – the height of building floor, m;
ν – speed of uniform movement of the freight elevators, m/s [4].

8.4 MORPHOLOGICAL ANALYSIS OF THE OWNERSHIP FORMS OF FIXED ASSETS OF MULTI-FLOOR VIRTUAL ENTERPRISES SYSTEM

Of the known forms of ownership of fixed assets in the multi-floor virtual enterprises systems can use the following: public, private, joint stock, cooperative [7]. Analysis of possible forms of ownership of fixed assets of the multi-floor virtual enterprises systems perform by means of a morphological matrix, shown in Tab. 8.1 [16].

Among various combinations of ownership forms of fixed assets of the multi-floor virtual enterprises system should highlight the following matrix: $A_3B_5C_6D_5E_6F_5G_7H_5I_1$ и $A_3B_6C_6D_5E_6F_5G_7H_5I_1$. The peculiarity of this combination of ownership of fixed assets of the multi-floor virtual enterprises system allows owners or tenants not only to produce products or perform services, but also, under certain conditions, to reside in adjacent rooms. In this case, the observed enterprises-homes transformed into a multi-floor virtual workhouses system by analogy with the existing system in England workhouses and which is now developed in the form of social entrepreneurship [19]. The ability to work at home in the multi-floor virtual workhouses in some cases, the application of environmentally friendly production, meeting the sanitary standards for residential premises, can be implemented in practice.

Tab. 8.1 Morphological matrix of ownership form of fixed assets of multi-floor virtual enterprises system

Description of the fixed assets		Ownership forms of fixed assets						
		1	2	3	4	5	6	7
A	Building	+	+	+	+	-	+	-
B	Apartments of enterprise	+	+	+	+	+	+	-
C	Transfer devices	+	+	+	-	+	+	-
D	Equipment and devices	+	+	+	+	+	+	+
E	Tools	+	+	+	+	+	+	-
F	Production equipment	+	+	+	+	+	+	-
G	Vehicle	+	+	+	+	+	+	+
H	Household equipment	+	+	+	+	+	+	-
I	Long-term planting	+	-	-	-	-	-	-

Legend:

1 – Public property.
2 – Private property.
3 – The joint-stock property.
4 – Cooperative property.
5 – The property of the enterprises.
6 – Rent.
7 – Leasing.

Source: [16]

CONCLUSIONS

The executed analysis the infrastructure for the multi-floor virtual enterprises system allows:

1. The constituent elements of infrastructure to be selected and their role in the maintenance of the main production to be analyzed.
2. The infrastructure for the multistory virtual enterprises on the floors of building to be distributed taking into account a type, kind, principles and forms of the main production organization.
3. The conditions for the harmonization of the vertical transport carrying capacity and of the performance of a multi-floor assembly manufacturing to be determined that eliminates the outages of main and auxiliary production, provides rhythmic work of freight elevators.
4. The offered morphological matrix of ownership forms of the fixed assets of the multi-floor virtual enterprises system to be used for their effective forming, including, as a system of multi-floor virtual workhouses.

REFERENCES

1 J. Czajka, K. Krot, M. Kuliberda. *Selected issues of production systems organisation and computer aided process planning: production system organisation*, Łódź: Wrocław University of Technology, PRINTPAP, 2011.

2 W. Davidow, M. Malone. *The virtual corporation: structuring and revitalizing the corporation for the 21 st century*, New York: Harper Collins College Publishers, 1992.

3 T. Dzhuguryan. „Design Features of Flexible Manufacturing Modules in Frame Construction." *Zeszyty Naukowe Politechniki Rzeszowskiej. Mechanika*, z. 84(2840), No 1, 2012, p. 21-25.

4 T. Dzhuguryan, Z. Jóźwiak. „Improving the Logistics of the Multi-Floor Assembly Manufacturing." *Technologia i Automatyzacja Montażu*, No 2, 2016.

5 M. Fujita, J.F. Thisse. *Economics of Agglomeration: Cities, Industrial Location, and Globalization*, Camdridge University Press, 2002.

6 Global Industry Classification Standard. Sector and industry group classification. [Online]. Available: http://www.msci.com/products/indexes/sector/gics/gics_structure.html [Accessed: Feb. 7, 2016].

7 B. Godziszewski, M. Haffer, N.J. Stankiewicz, S. Sudoł. *Przedsiębiorstwo. Teoria i praktyka zarządzania*, Warszawa: PWE, 2011.

8 V. Gritsenko, T. Witkowski, L. Timashova. „Intellectualization Problems of Virtual Enterprises." *Ekonomika i Organizacja Przedsiębiorstwa*, No 5, 2015, p. 3-11.

9 C. Handy. „A Glimpse of the Invisible Organization." *Director*, October 1994.

10 M. Januška, O. Kurkin, A. Miller. „Communication Environment for Small and Medium Enterprises." *Ibima Business Review*, 2011, p. 1-8.

11 A. Mowshowitz. „Virtual organization." *Association for Computing Machinery. Communications of the ACM*, New York: Sep 1997, p. 30-34.

12 A. Sullivan, M.S. Steven. *Economics: Principles in action*. Upper Saddle River, New Jersey 07458: Pearson Prentice Hall, 2003.

13 E. Westkämper. *Towards the Re-Industrialization of Europe. A Concept for Manufacturing for 2030*. Berlin: Springer, 2014.

14 H.P. Wiendahl, J. Reichardt, P. Nyhuis. *Handbook Factory Planning and Design*, Berlin: Springer, 2015.

15 H.A. Wüthrich, A.F. Philipp. „Virtuelle Unternehmensnetzwerke - Agilität als Alternative zur Unternehmensgröße?" *Management Zeitschrift*, No 11(67), 1998, p. 38-42.

16 F. Zwicky. *Morphologische Forschung.* Winterthur: Neuaufl. Baeschlin, Glarus 1989.

17 В.И. Вершинин. *Эволюция промышленной архитектуры: учеб. Пособие*, Москва: Издательство Архитектура, 2007.

18 Э. Весткемпер. *Введение в организацию производства.* Э. Весткемпер, М. Декер, Л. Ендоуби, А.И. Грабченко, В.Л. Доброскок; пер. с нем.; под об. ред. А.И. Грабченко. - Харьков: НТУ ХПИ, 2008.

19 Я.С. Гришина. „Социальное предпринимательство как инновационно-правовая основа обеспечения имущественных потребностей." *Вестник ННГУ:* 2013, No 3-2 Электронный доступ: http://cyberleninka.ru/article/n/sotsialnoe-predprinimatelstvo-kak-innovatsionno-pravovaya-osnova-obespecheniya-imuschestvennyh-potrebnostey [Accessed: Feb. 27, 2016].

20 А.Е. Ромашкин. „Распределенное производство. Состояние и перспективы развития." *Представительная власть - XXI век: законодательство, комментарии, проблемы*, №3, 2007, p. 42-44.

21 Г.А. Швыданенко, А.Ю. Рыкунич. „Система управления инфраструктурой предприятия." *Проблемы экономики,* No 2, 2013, Электронный доступ: http://-cyberleninka.ru/article/n/sistema-upravleniya-infrastrukturoy-redpriyatiya [Accessed: Jan. 17, 2016].

INFRASTRUCTURE FOR MULTI-FLOOR VIRTUAL ENTERPRISES SYSTEM

Abstract: *The multi-floor manufacturing is widely used in the megacities with high-density population due to the limited areas for industrial development and also the necessity of unloading transport streams. The article gives the analysis of an infrastructure for the multi-floor virtual enterprises system that allows allocating the components and studying their role in maintaining the main production. The conditions for the harmonization of the vertical transport carrying capacity and of the performance of a multi-floor assembly manufacturing are determined. The morphological analysis of ownership patterns of the fixed assets for the multi-floor virtual enterprises is defined. The article offers to define the enterprises-homes as system of multi-floor virtual workhouses.*

Key words: *system of multi-floor, flexible manufacturing, time of cycle, elevators, performance*

INFRASTRUKTURA MULTI – FLOOR W SYSTEMACH WIRTUALNYCH PRZEDSIĘBIORSTW

Streszczenie: *Wytwarzanie multi-floor jest szeroko stosowane w wielkich miastach o dużej gęstości populacji z powodu ograniczonych obszarów dla rozwoju przemysłu, a także konieczności usprawnienia strumieni transportowych. Artykuł zawiera analizę infrastruktury, dla wielokondygnacyjnego systemu wirtualnych przedsiębiorstw. Analiza ta umożliwia przydzielanie komponentów i badanie ich roli w utrzymaniu produkcji głównej. W artykule ustalono warunki dotyczące harmonizacji pionowego transportu, ładowności oraz wykonania produkcji montażowej multi-floor. Ponadto przeprowadzono morfologiczną analizę wzorców własności środków trwałych dla wielokondygnacyjnych wirtualnych przedsiębiorstw. W artykule proponuje się zdefiniowanie przedsiębiorstwa - domu, jako systemu multi-floor wirtualnych przedsiębiorstw.*

Słowa kluczowe: *system multi-floor, elastyczna produkcja, czas cyklu, transport pionowy, osiągi*

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