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AUTOMATIC TECHNOLOGICAL LINES FOR PRODUCTION OF PRECAST CONCRETE

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FOREWORD

The production of precast concrete got underway on a large scale after the Decree of the Soviet Government in 1954, and by 1970 its output increased by 30 times and ran up to 84 million m^3, and in 1990 reached 146 million m^3. In terms of the use of precast concrete items the USSR was ahead of more developed countries. What is more, its production evolved into an independent branch of the construction materials industry. Along with the increase in production and use of precast concrete there was advanced its manufacturing method. There was carried out the unification of key parameters of buildings and structures for various purposes. On its basis there were developed and implemented standard components and constructions.

In 1980, it was about time to reconstruct plants for the production of concrete and reinforced concrete articles, as there was long past time to develop and apply high performance technologies which made it possible to actualize the main advantage of such structures i.e. highly mechanized and automated methods of their manufacturing with proper quality control. At the construction site these elements are only mounted, which drastically reduces the construction time, increases labour productivity and allows to extensively apply new functional materials (lightweight cellular concrete, decorative ceramics, etc.).

Rotary as well as rotary and conveyor lines make it possible to increase labour productivity by ten times. Applying this principle, academician L. Koshkin developed a technology that revolutionized engineering and other industries, especially the defence one. Unlike conveyors, extending in a line, rotary rig positioned in a carousel requires several times less production area. In order to further automate production and increase labour productivity rotary lines were arranged into rotor and conveyor ones on which the details (materials) were transferred from one rotor to the other.

The major operations when producing concrete items are: concrete mixing, production of reinforcement cages, reinforcing, moulding and their rapid hardening. Reinforced concrete articles are manufactured in several ways: bench, flow-line and conveyor ones. In his monograph academician B. Gusev, who is a father of the industry, looks at the practices of rotor and conveyor lines development for the production of a new type of reinforced concrete. As the result, there were achieved high rates to intensify the production of reinforced concrete structures which are delivered to

construction sites in finished form. These items are production elements in the process of modular and monolithic erection of buildings and structures. The monograph examines the projects of highly mechanized and automated production lines for construction structures implemented under B. Gusev's supervision. Rotary as well as rotary and conveyor lines which proved to be highly efficient are compared with the bench method, which acquired great importance at early stages in the mass production of details in cassettes.

Using this manufacturing method, the details are produced in vertical form-cassettes, as a series of compartments with steel walls. On the cassette-installation the whole production cycle of thin-walled items is fully carried out, i.e. reinforcement fitting, filling of the compartments with concrete mix, its hardening. For this purpose, the cassette unit has a vibrating device and devices for steam curing and electric heating of details in the process of hardening.

Flow-line production method is that all operations of detail manufacturing, cleaning and greasing of moulds, placement of reinforcement and concrete, hardening and demoulding are performed in special platforms which create a special flow-line. The item together with the mould is subsequently moved through the conveyor from one position to another with different time intervals, depending on the operation time from a few minutes (greasing of moulds) to several hours (hardening in the curing chamber). The main advantage of flow-line production mode is the versatility of the major technological equipment. For example, manufacturing of new forms have low cost, which means, that one can quickly switch to another type of product release. This manufacturing method for reinforced concrete is the most widespread in Russia. It is economically expedient for plants with a wide assortment of products, and the average annual output of up to 100 thousand m^3.

For all these reasons, the main control object (considered in the book in detail) is the flow-line conveyor and such production methods, which are characterized by maximum dismemberment of technological operations and represent a more advanced flow technology which enables maximum mechanization and automation of basic operations.

Taking into account the necessity to considerably reorganize current production of reinforced concrete in Russia, the monograph by B. Gusev is especially relevant, particularly due to the author's extensive experience and magnificent comparative material, described in the book.

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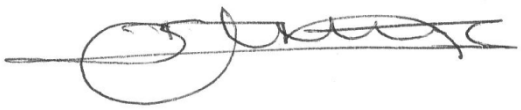

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INTRODUCTION

The author of this paper, since the late 60-s of XX century, actively worked on different areas in technology of concrete and reinforced concrete, especially on the issues of strength of concrete as composite material. In the early 70-s, works on vibration compaction of concrete mixtures, issues of mechano-chemical activation of concrete mixture, problems of acceleration of hardening of concrete mixtures, have begun. In the industry of precast concrete, low-frequency vibration modes were designed and widely implied, including stroke-vibrational equipment. Altogether it allowed to create concept of continuous production line on production of reinforced concrete products of many types, and to start works on automation of technological processes to provide production of most various types of products.

Automation is most efficient on enterprises with continuous technological processes. It significantly reduces the influence of subjective factors on the technological process, and provides an opportunity to reach more rhythmical and highly productive work. Automation of technological processes in production of reinforced concrete products and structures should:

- reduce consumption of raw materials, electric power, fuel, water and other materials;
- raise labor safety and improvement of working conditions for staff;
- scale back the number of staff, directly occupied in production and control;
- improve production quality.

These are the goals of works by the leading scientific-technology, project, design, and production organizations in design of automatic production lines. In this paper, main trends when creating automatic lines are being analyzed; technical solutions of particular lines are given, and industrial experience of their use is summarized.

There was developed a technological platform for technical reequipment of precast concrete industry with the participation of a number of research and development as well as project institutions under the supervision of the Laboratory Head of technological advancement for precast concrete of Concrete and Reinforced concrete Research Institute of the USSR Construction Committee.

The book may be useful for science workers in technology of concrete and reinforced concrete, engineers of design organizations, as well as postgraduate students, and students of construction professions.

ABBREVIATIONS

— Gosstroy of USSR - State Construction Committee of the USSR
— Gosstroy of BSSR - State Construction Committee of Belarusian SSR
— Gosstroy of Ukrainian SSR - State Construction Committee of Ukrainian SSR
— Minstroy of USSR – USSR Ministry of Construction,
— Minsevzapstroy of USSR – USSR Ministry of Construction in North-West regions
— Minuralsibstroy of USSR – USSR Ministry of Construction in regions of Urals and Siberia;
— Minyugstroy of USSR – USSR Ministry of Construction in Southern regions
— Minvostokstroy of USSR – USSR Ministry of Construction in the regions of Far East
— Minmontazhspetsstroy of USSR - USSR Ministry of Erecting and Construction Works
— Mintranstroy of USSR – USSR Ministry of Transport Construction
— Minstroydormash of USSR – USSR Ministry of Machine Building for Road and Construction Machines
— Minselstroy of USSR – USSR Ministry of Agricultural Sector
— NPO – Scientific-Production Association
— PSO – Production-Construction Association
— MGO – Inter-regional State Association
— PO – Production Association
— KPP – Large-Housing Enterprise
— TP - Territorial Association of Construction Enterprises
— PPO – Project-Industrial Association
— NIIZhb – Concrete and Reinforced Concrete Research Institute
— VNIIZhB - All-Union Concrete and Reinforced Concrete Research Institute
— TsNIIEP of House Construction – Central Scientific-Research Institute of Experimental Project of House Construction of USSR
— Giprostrommash - State Project Institute of Construction Engineering
— NIISP – Scientific-Research Institute of Construction Industry
— NIIES - Scientific-Research Institute of Economy in Construction
— GPKTI – State Project-Construction Technological Institute

— NIL FKhMM and TP - Scientitic-Research Laboratory of Physical and Chemical mechanics and Technological Processes

— PI – Project Institute

— KTB – Special Design-Technological Bureau

— SKB – Special Design Bureau

— KB – Design Bureau

— EKB – Experimental Design Bureau

— NS – outer wall panels

— VS – inner wall panels

— BSU – concrete-mixing unit

— ML – mechanized line

— T.P, t.p. – technological project

— SMZh – machines for the production of precast concrete according to the classification of USSR Minstroydormash

— MTMS – mechanized technological machine for welding.

1. PRODUCTION OF PRECAST CONCRETE, AND EXPANSION OF USE OF PROGRESSIVE TYPES OF TECHNOLOGICAL EQUIPMENT AND SPECIALIZED LINES

The industry of precast concrete of USSR provided to 1990 output of more than 140 million m3 of structures and products, its main production assets amounted about 11 billion roubles. In the industry of precast concrete, annual consumption was: 50 million tons of cement, 9 million tons of metal, 12 million tons of conventional fuel. The branch included about 6000 enterprises, and over 1 million workers [1].

The structure of enterprises of precast concrete according to capacities, m^3 per year:

under 20……15%
21-50……...20%
51-100…….28%
over 100……...37%

The main volume of production (62,8) produced in enterprises, capacity of which was within 20-150 thousand m^3. At the same time, the level of power use, provided by the regulations of technical design (94,3 %) reached only about 30% enterprises of construction ministries. The level of capital productivity constantly reduced, annual output per 1 worker remained on the level a bit over 200 m^3.

Structure of use of main technological models of production was characterized by the following indices:

Production technology	Total volume,%
Assembly line - aggregate	55-58
Stand, cassette-conveyor	30
Conveyor	12-15

The analysis shows that coefficient of use of the main equipment on assembly line – aggregate and conveyor lines in technological cycle was extremely low: for vibratory plates it was 25-30% of total period of rhythm of work of lines, for concrete pavers, 32-35% of total period of rhythm of work of line, for smoothing machines, 34-38%.

This was connected with high part of manual labour, used for laying and smoothing of concrete mixture, cleaning and lubricating of moulds, removal of form etc., what, together with high noise level during operation

of vibrational machines and increased temperature near steam curing chambers and cassettes, makes the labour of workers socially unattractive.

In the industry of precast concrete, over 3 million tons of technical equipment was used. It included 2 million tons of moulds, and the change of moulds annually consumed over 600 thousand tons of steel. According to the data of NIIES (Scientific Research Institute for Power Structures), the age of the used equipment was: under 5 years, 36 %; from 5 to 10 years, 26,9 %; from 10 to 15 years, 13,8 %, and over 15 years, 23,1 %.

The situation is connected with insufficiently developed industrial framework, producing new equipment. Its development remained behind the growth of demands of precast concrete enterprises. E.g., the deficiency of welding equipment produced by electro-technical industry, forced construction ministries and separate enterprises to design and to make equipment, unusual for the type of their production and technical opportunities. The possible solution of this problem could be uniting efforts and resources of the branch, creating united system for construction and production of equipment on the modern science and technological basis.

On the enterprises of precast concrete, there were installed over 51 thousand curing pits, 900 automatic and semi-automatic, and 370 tunnel steam-curing chambers, the major part of them used inefficiently. At the same time, actual consumption of steam exceeded 500 kg/m^3 of concrete. On some enterprises, power consumptions differed several times. Such range of consumption convincingly witnessed the presence of reserves available for reducing consumption of fuel and energy resources.

Acceleration of scientific and technological progress in reinforced concrete industry for the near period must be developed in two main aspects:

- reconstruction of operating enterprises with the purpose of extensive implementation of progressive technological processes, modernization of existing equipment, and account of the experience of work organization of the leading factories in the branch;
- modernization of enterprises on the basis of implementation of highly-mechanized and automated production lines.

In solving the issues on partial reconstruction it was necessary to organize, on all enterprises of precast concrete, storing of chemical additions and their introduction into concrete mixtures with use of automated equipment. It provided mass implementation super-plasticizers and efficient plastisizers (S-3, Dofan, 10-03, 40-03, LSTM-2, NIL-21. with the purpose of increase of labour productivity, saving of cement, increase service life of equipment, and improvement of social conditions of labour.

In the production of reinforcement, factories of precast concrete were underwent mass implementation of straightening-and-cutting machines for cutting and bending of reinforcement, production lines for making flat fabric reinforcement, automatic lines for butt-seam welding. Later, the use of highly-productive automatic production lines was implied, with robotized modules and manipulators, for wasteless processing of reinforcement steels. Winding machines had great perspective as they may be used within completely automated cycle of reinforcement works.

Taking into account the deficiency of steel, it was necessary to use in large numbers the moulds of progressive types: drain pans with diagonal web, and prestressed moulds with three-point type of support, with elastically working elements, etc. It was reasonable to increase the volume of use of non-metallic moulds, including reinforced concrete ones, with polymer working layer for making products of average- and small-series types, as well as facade goods with relief or complex outline.

The reconstruction of forming posts was made with preferred use of low-frequency vibratory plates, vibratory nozzles, vibratory insert liners, and vibratory moulds.

It should be mentioned that output volume of serial vibratory plates did not satisfy the demands of enterprises of precast concrete. So, their design, production and implementation was carried out by many construction ministries, what considerably reflected the duration of forming cycle, which virtually remain unchanged for the 10-16 years, and exceeds standard index (norm) by 15-20%. Implementation of vibratory plates (which are being designed by Scientific and Technology Institute for Concrete and Reinforced Concrete of USSR Gosstroy (NIIZhB), and by Giprostroymash) with controlled mode, will make it possible in the future to increase productivity of equipment 1,5 - 2 times, reduce noise level down to 85 dBA, and specific power consumption from 5 to 1,5 kWh per ton.

In the area of thermal treatment of concrete it was reasonable to broaden implementation of electric thermal treatment. Thus, change of steam in cassette moulds with electric heating devices provides heating-through of products with power consumption 60-70 kWh per m^3 of concrete (1 kWh is equal to 864 kkal). The same efficiency has electric heating of concrete in chambers of tunnel and slot types, performed by heating elements or rod-and-tube heaters, installed on the walls of the chamber. Rather progressive types of heat-carriers are aerosol systems with thin grinding of steam in heat processing cameras.

In the regions to further south than northern latitude, it was reasonable to broaden use of heliotechnology. In the areas where natural

gas is not deficient fuel, it is very promising technology to heat-through precast concrete products in chambers by products of gas combustion.

To increase quality of products, it was necessary to complete equipping of enterprises of precast concrete production, with appliances and devices for control over each operation and outgoing quality control. It is planned to design and perform serial production of automated installations and quality control systems, including those based on micro-processor equipment.

Priority of areas for modernization is connected with dynamics of development of use of precast concrete in a whole, and on separate types of structures. The main types of reinforced concrete goods (about 100 million m^3) are fundamental blocks, elements of frameworks, inner and outer wall panels, and floor slabs. For making those elements, there were created and prepared for wide-scale implication, automatic and high-mechanized production lines with output per 1 man, exceeding average output 2,5-5 times (500-1000 m^3 per 1 man per year).

In the Table 1, technical and economical indices of production lines are given, and supposed volumes of their use, including the use in the future.

Table 1

Production line, and the place of implementation of the first line	Technical-economical indices			
	1985	1990	Прогноз на 1995	
1	2	3	4	5
Automatic rotor-conveyor lines for fundamental blocks and walls of cellar, output 20 thousand m^3 per year, USSR Production association Urkvodzhelezobeton, Kakhovka	3/120	10/400	20/800	Reduce of labour expenditures 3-5 times, specific metal consumption 2-3 times, economic efficiency, 5 roubles per m^3
Highly-mechanized cassette-conveyor lines for production of inner wall panels, output about 30 thousand m^3 per year, USSR Minsevzapstroy, USSR Minuralsibstroy, USSR Minvostokstroy	4/120	40/1200	100/3000	Reduce of labor expenditures 2 and more times, metal consumption 3-4 times, economic efficiency,2,36 roubles/m^3

1	2	3	4	5
Conveyor lines for production of wall panels in horizontal position, including the usage of superplasticizers, USSR DSK-4, Moscow	1/30	10/300	20/600	Reduce of labor expenditures 2 times, metal consumption 3 times, economic efficiency, 5 roubles/m^3
Lines for production of floor slab panels, conveyor, USSR ZhBI №6 PPO Mospromstroymaterialy	1/90	10/900	20/1800	Reduce of labor expenditures 2-1,5 times, metal consumption 1,5-2 times, economic efficiency, 2-3 roubles/m^3
semi-conveyor, USSR MGO Stroymash, serially	1/40	20/800	40/1600	economic efficiency, 2-3 roubles/m^3
Conveyor lines for production of wall panels, including three-layer, USSR DSK-1 PSO Mosstroy series	1/40	20/800	60/2400	Reduce of labor expenditures 1,5 times, economic efficiency up to 3 roubles/m^3
Conveyor and stand lines of elements of framework and span panels USSR ZhBI-18 PPO Mospromstoymaterialy, ZZhBI (Reinforced concrete plant), Brovary	1/20	20/400	60/800	Reduce of labor expenditures 1,5-2 times, economic efficiency up to 3 roubles/m^3

In reconstruction of enterprises for production of multi-void plates, it was necessary to broaden the mastering of conveyor lines with productivity 90 thousand m^3 per year (with 3-shift working process), developed by SKTB PPO Mospromstroymaterialy, and implemented on ZhBI-6.

At the present time, on the enterprises of construction industry, became widely used production conveyor lines with transverse position of forms-trolleys for making outer wall panels, floors, complex coverings, multi-void floors, etc.

All lines are placed in spans 18 meters, with length from 120 to 144 meters. Most lines made in two-level type.

Production lines in Omsk are made in kind of horizontally-confined conveyors. Cost of tunnel chambers for heat treatment is reduced 3 times (150 thousand roubles instead of 450 thousand roubles with two-level type). Due to the increase of the number of technological posts to 11-12 instead of 6-7, on technological lines with longitudinal placements of moulds, technological mode is shortened from 25-30 to 18-20 minutes. Opportunity of making in this rhythm of multi-component three-layer and complex panels is obtained. Significantly increased capacity of tunnel chamber: one chamber with prechamber changes 3-4 chambers, necessary for longitudinal placement of moulds.

Productivity of the line and pick-up of output from 1 m^2 of production area in this case will increase 1,5-2,5 times.

In the paper [1], summaries are given on the main technological lines in production of precast concrete. It should be mentioned that high efficiency of modernization of the precast concrete industry may be reached only as the result of application of new technologies, which provide significant reduction of labour expenditures and material costs, and improvement of social conditions of labour.

2. NEW LAYOUT SOLUTIONS FOR PRODUCTION LINES OF PRECAST LARGE-PANEL CONSTRUCTION

Efficiency of any industrial production, including the enterprises of precast large-panel construction, significantly depends on timely renewal of active part of the main funds, making it possible to implement the possibilities of progressive technologies. Modernization of industry is being made, as a rule, within technical re-equipment, or reconstruction of industry. The opportunities of technical re-equipment of precast large-panel construction, besides the limited choice of highly-productive equipment, is often restricted by architectural planning and layout technological solutions of the existing plants. Their major part is built according to typical projects, designed 10 -15 years ago, and do not match modern and perspective level.

Each project is designed for certain specialized production, such specialization, along with some advantages has a range of serious drawbacks:

- length of production lines does not differentiated depending on complexity of making of this of that type of products, as it is restricted by the length of spans;
- insufficiently efficient use of production areas (shadow areas along columns), crane equipment and transportation conveyors;
- difficult ways of solving transport layouts for moving materials and components, when it is necessary to deliver them to all spans. From the point of view of placement of equipment and use of production areas, 18-meter span is of small efficiency. E.g., in case of parallel placement of conveyor with transverse placement of form-trolleys and heat treatment chamber, it is necessary to increase the span up to 24 meters.

It should be mentioned general low level of mechanization and automation of production lines, difference in types of technology and equipment, what provide insufficient flexibility of production and high operating costs. For this reason, level of project decisions of the existing enterprises of precast large-panel construction cannot provide planned increase of such technical and economical indices as increase pick-up of products from production areas and growth of labour productivity 1,5 - 2 times.

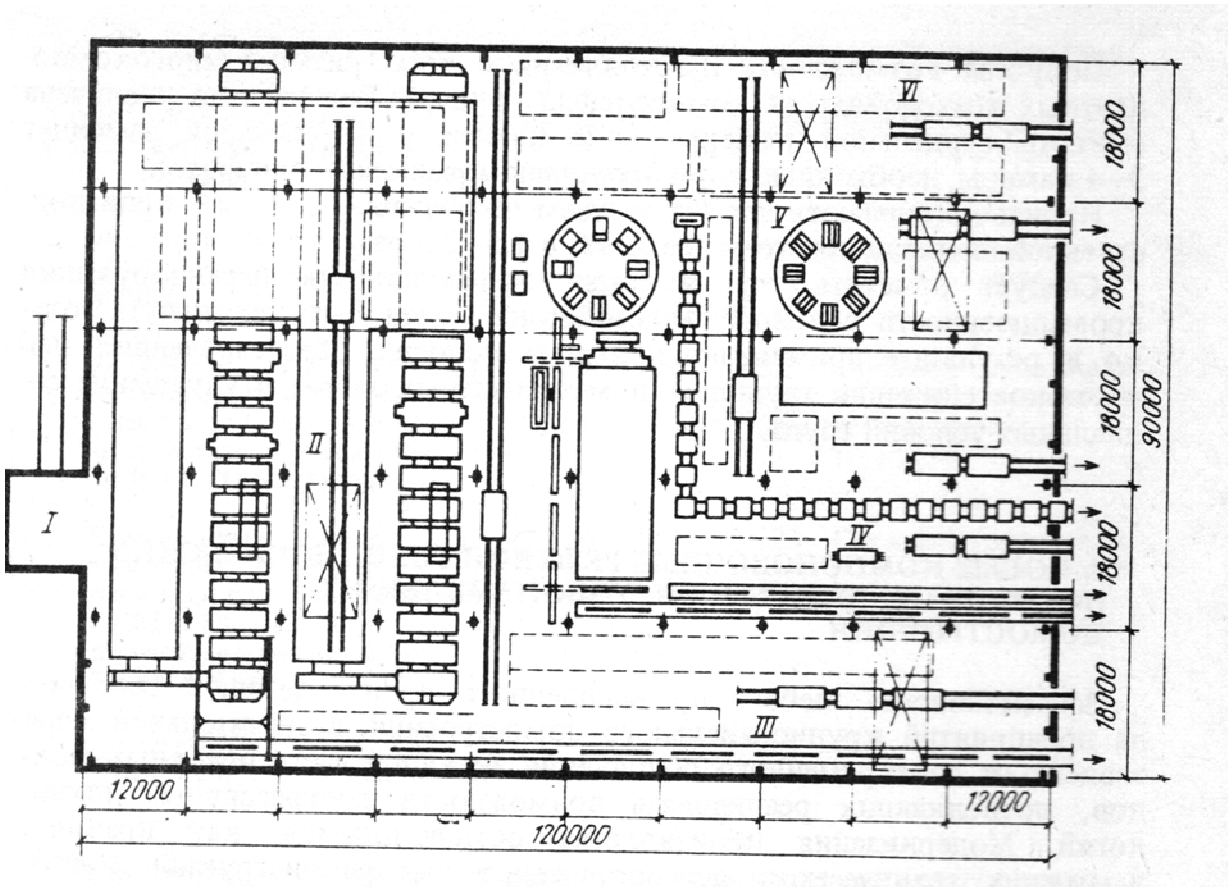

Fig.1. Arrangement solutions of the factories of new generation, with capacity 200 thousand m^2 of total area per year.
I - concrete mixing unit; II - production of outer wall panels; III - finishing and export of finished products; IV- production of inner wall panels and floor slab panels; V - production of room (box) units; VI - reinforcement production.

To solve these problems, principally new approach is necessary to layout solutions of enterprises of precast large-panel construction, as well as design, implementation of new and efficient technologies and highly-productive equipment, i.e., equipment systems, which compose a united complex.

Team of NIIZhB and KTB Stroyindustriya with participation of A.Yakushev design bureau on reinforced concrete and Project Institute № 2 headed by the author of the book, technical solutions were designed on the new generations of factories of precast large-panel constructions, with capacity of 200 and 400 thousand m^2 of total area per year (Fig. 1).

Technological solutions provide creating new generation factories of precast large-panel construction with annual capacity 200 and 400 thousand m^2, as well as reconstruction of existing enterprises, e.g., factory of precast large-panel construction according to the typical projecty 409-

13-11 for production of 200 thousand m^2 products per year. The main principle of the projectible factories is combination of transport flows with production lines, when transport-production lines on each type of products form combined lines [2,3].

Production of mass goods, of complicated structure and finishing, e.g., outer wall panels, which demands large numbers of production lines and posts, is being performed on outer, the most long lines. In process of reduction of complicatedness of products, length of line becomes shorter. The shortest lines comply with stand technology. Instead of 5 18-meter spans, there are 12 specialized spans. This provides high degree of specialization of production lines and flows, as well as opportunity of automation of technological operations. The inherent to the existing technology concentration in one span of production of outer wall panels, conveyors of forming and finishing, is being excluded; transportation, intermediate storing and technological completion of concrete, reinforced concrete, finishing materials, heating material, cabinet work, window-sills etc., what becomes the main reason of decrease of production capacity of factories of precast large-panel construction.

Proposals include a number of new technological solutions, providing qualitative increase of technical-economical indices:

- main part of technological equipment, and, particularly, forming containers, are placed on the same level with mark 0.00, what provides mobility of reconstruction, and reliability of operation;
- tunnel chambers of thermal processing prolonged under reinforcement section, and, on their overlapping, stands are put for assembling frameworks directly to the posts of laying into the form;
- as a heat carrier, aerated water or cavitational heating is being used, with temperature 90°C in closed circuit, what excludes necessity of boiler-houses, heating mains, sewerages, condensate return, and, as the source of power, there may be used natural gas, electric power, thermal waters, heliosources, steam;
- reinforcing cagesap of inner wall panels and floor slabs is made by the method of continuous winding, including with pre-tension;
- there are taken forming conveyors with transverse placement of moulds, what increases amount of posts and capacity of chambers;
- moulds of outer wall panels are made with spring-loaded boards, what increases quality of products, increases between-repairs period of moulds of board equipment;

- delivery of concrete is performed by concrete pumps, what provides benefits of production areas up to 15%, addressed delivery of expanded-clay concrete and finishing layer is performed by trolleys;

- for compaction of concrete, stroke-vibrational installation of through-going type with horizontal oscillations, with reduced noise level, what makes it possible to reduce installed capacity and decrease metal consumption of moulds;

- layout of concrete is performed with suspended coordinate-turning concrete spreaders;

- forming of the upper layer is made by vibrational installation of pressure contact forming, which provides compaction and quality of surface with speed up to 2 meters per minute;

- as a heater, latex-polystyrene composition is used;

- for making inner wall panels and floor slabs cassette-conveyor line is used with one-stage thermal treatment, what makes it possible to increase pick-up of products from production areas by 2,5-3 times in comparison with other technological layouts;

- production of volumetrical elements is performed on rotor-conveyor line.

The use of new technical solutions makes it possible to increase labour productivity by 2,5 times, pick-up from 1 m^2, by 2,5 times, to decrease capital investments by 2 times, provides mastering by enterprises 100% planned production capacity (Table 2).

NIIZhB of USSR Gosstroy with VNIIZhelezobeton (Institute for reinforced concrete), A.A. Yakushev Design Bureau on reinforced concrete, Project Institute № 2, have also designed technical solutions for enterprises of precast large-panel construction with capacity 70 and 140 thousand m^2 of total area per year for making products of other systems. Such technical solutions are based on new approaches and principles of general configuration solutions of industrial production, production lines, and equipment:

Table 2

Indices	New generation plants		Plant on typical project 409-13-8
	high capacity	average capacity	
Annual capacity, thousand m^2 of total area	400	200	120-160
Annual capacity, thousand m^3	271	141	108
Production area, m^2	14100	8400	12400
Amount of main production workers	188	106	178
Weight of technological equipment, tons	3950	2600	2830
Including moulds	2690	1680	2000
Capital investments - total, thousand roubles	6246	-	-
Including:			
cost of construction part	2500	-	-
installation work	405	-	-
equipment	3341	-	-
Pick-up from 1 m^2 of production area, m^3	19,2	17,3	8,7
Labour-intensiveness, man-hour/m^2	1,4	1,46	3,3
Metal consumption, kg/m^3	14,5	17,9	26,2
Including for moulds	10	11,5	18,5
Heat consumption during the use, Gkal/m^3:			
traditional types of energy	0,1	0,11	0,14
solar	0,077	0,08	-
Capital investments per unit power, roubles/m^2	15,62	-	27,28
Yield rate, %	15	-	-
Pay-back period	5,7	-	-

- three-level manufacturing building: 1 level (elevating), chamber of heat treatment, 2 level, forming production, 3 level, reinforcement production;

- rational organization of technological flows, readjustment of moulds, and reduction of span length down to 120 m;

- automated cassette-conveyor line of rotor type for production of inner wall panels;

- rotor line for production of sanitary engineering cabins and elevator shafts;

- automated system of accepting, keeping of raw materials, and preparing concrete mixtures with addressed delivery, and use of preheated mixtures (in production of inner wall panels);

- robotized installations of continuous reinforcing;

- forming equipment, excluding hand labour, and increasing quality of products (vibratory plates with controlled parameters, concrete spreaders with dispensers, rotor-type thrower, low-frequency installations of vertical forming with vibro-drive of multicomponent oscillations);

- use of moving mixtures with super-plastisizers in production of three-layer outer wall panels, volumetric products, additional elements**;**

- heat processing by oil heating [2].

The main building of the factory with capacity 140 thousand m^2 is an assembly of forming production departments of 5 spans 18x120 m, attached concrete-mixing department of tower type, reinforcement department on the 2 level over forming spans. The line for concrete delivery is places over forming span, what, in combination with configuration solutions of production lines, made it possible to reduce the length of the spans down to 120 m.

Considerable changes are being put into production and delivery of reinforcement products to the forming posts. Reinforcement department 30 meters in width and 72 meters in length, with packaging site, is placed on the mark + 6 m of the industrial building. Automated store of metal continues the reinforcement department, and is equipped with piler-crane. For making reinforcement products, it is mainly used serial equipment for preparing and welding of reinforcement steel according to the wasteless technology. Besides this, into the equipment, there are included automates for straightening, cutting and bending of bars, making embedded fittings etc., widely used packing and containerization of products.

Volume of reinforcement works and amount of equipment are reduced about 50%, and production area, due to the use of winding of reinforcement cages directly on forming posts, has changed, in comparison with the similar type, by 20%.

The necessary stock of reinforcement products for forming spans is placed on the packaging site on 2 level. The ready reinforcement

products are being delivered to production lines by suspended transport, and by manipulators directly to the assembling posts. As a result, the number of workers occupied in the department, reduced from 30 to 12 men, what provided reduction of labour costs 2,5 times, and created reserve for increase of volume of reinforcement works.

In distinction of the project of the factory for 140 thousand m^2, for the factory with production capacity 70 thousand m^2 there were taken decision to change making of cavitated floor plates with continuous ones. Production of construction structures on this factory is organized in such spans:

- production of inner wall panels and continuous floors on cassette-conveyor line (similar for the factory with capacity 140 thousand m^2);
- production of outer wall panels on two-branch conveyor line, consisting of 6 posts. The equipment is similar to the conveyor for 140 thousand m^2. Due to the increase of the rhythm, it is provided to combine the operations. The number of workers is 8 men per shift. In the same span, it is provided to produce additional elements in special moulds with service by five workers;
- production of volumetric elements in stand moulds and horizontally-formed additional elements on semi-conveyor line. The span is served by 20 workers;
- reinforcement department 30x54 meters in size, placed on the 2 level. The technology of products is similar to the factory with 140 thousand m^2. Department is served by 8 workers.

Implementation of technical solutions for the factory of precast large-panel construction with capacity 140-160 thousand m^2 of total area per year will make it possible:

- reduce labour costs and increase labour productivity 1,7- 2 times;
- increase pick-up from 1 m^2 of production area by 40-60%;
- reduce specific capital investments by 15-20%;
- reduce power consumption 1,5 times.

Mastering of new principles of configuration solutions of factories of precast large-panel construction with taking into account flexibility of technological processes, and, at the same time, with implementation new and efficient technologies, equipment, methods and means of control, quality control, makes it possible to significantly increase technical level of production of enterprises of precast large-panel construction of various capacity.

Principally new opportunities in labour output (up to 10 times), considerable improvement of technical-economical indices appear in

production lines for production of reinforced concrete products, which are based on rotor, or ring, principle.

It should be supposed that implementation of the principle of rotor, or ring technology for making products of precast large-panel construction, will make it possible to sharply increase the efficiency of production. Such approach will considerably change traditional concepts of enterprises of precast large-panel construction, will demand to reassess configuration solutions for the main department, production lines. Specialists of SKTB Stroyindustriya of Minsevzapstroy of RSFSR, and NIIZhB of USSR Gosstroy have developed technological solutions on linking of rotor technology in production of components of precast large-panel construction.

In this process, the following goals were aimed: to provide significant increase of labour productivity with saving on material and power resources; to improve labour conditions on the basis of complex mechanization and automation of production processes due to configuring progressive technological lines and main equipment (both serial and non-standard).

In development of technical solutions, there were taken the following main principles:

- making products with rotor or close to it technology for providing compactness of lines, reduction technological metal consumption, increase of the level of automation of processes;
- use of floor technology with the purpose of simplifying construction part, considerably increasing costs on building and construction works during technical re-equipment of the existing enterprises;
- making of the main volume of flat products by the method of vertical forming for provision of compactness of production lines, reduction of their metal consumption, provision of quality of products (preciseness of geometrical sizes, improvement of quality of surfaces);
- excluding of steam as heat carrier during thermal treatment of products, and change of it with more efficient "oil" heating with the purpose of economy of power resources, improvement of labour conditions;
- placing of making reinforcement products directly to the technological cycle of forming for reduction of production areas, improvement labour output and saving power resources, reduction of length of transport flows;

- excluding traditional concrete-mixing units, and use of local units, placed close to the sites of consumption of concrete mixture (with transportation of it by high-speed bucked), with the purpose of reduction of capital investments for construction, reduction of overloads of materials, and creating automatic system for control and transportation of concrete mixture;

- maximum use of "craneless" technology (excluding use of bridge crane) for reducing labour costs, operating and power costs;

- use of heated concrete mixtures, use of chemical additions, accelerating agents and plastisizers, with the purpose of reduction of general cycle of thermal treatment and increase quality of products;

- use of floor-placed hoisting transport on the finished product storage for improvement of configuration conditions, reduction of capital investments, decrease of operating costs.

Table 3

Indices	Magnitude of the indices		
	typical project of factory, capacity 140 thousand m^2	new technological solutions for factories, capacity, thousand m^2	
		140-160	70
1	2	3	4
Pick-up from 1 m^2 of production area, m^2/m^2:			
of forming department	11	13/14,8	10,8
including reinforcement department	9	13/14,8	10,8
Labour costs, man-hour/m^2			
of workers	5,1	2,5/2,2	3
of the working	5,5	2,9/2,5	3,6
Specific metal consumption, kg/m^2			
total	22,6	21/18,6	28,6
of forms	15,2	13,4/11,8	17,3
Annual output, m^2 per man			
per worker	408	707/808	686
per the working	376	622/711	579

1	2	3	4
Specific capital investments, roubles/m^2			
in equipment and moulds (forming and reinforcement production)	18,1	17,1/15	22,9
in construction part of building (forming and reinforcement production)	14	10/8,8	12
Power consumption on hear treatment, roubles/m^2	1,35	0,9	1,35
Installed capacity of equipment, kW	1910	2000	1200

These main principles are also implemented in design of technical solutions of factory of precast large-panel construction with capacity 200 thousand m^2 of total area per year. Volumetric-planning and constructional solutions of the main manufacturing building are taken with account of progressive technological requirements, and provide the most rational use of production areas and volumes. The given main technical-economical indices of factory of precast large-panel construction with capacity 200 thousand m^2 of total area per year, working with rotor technology, prove the efficiency of the taken technical decisions:

Index	Value of index
1	2
Annual production output	
products of precast large-panel construction, thousand m^3	181,72
in actual wholesale prices, thousand roubles	7683,12
Number of workers	347
Including:	
workers	277
engineering-technical workers, junior service staff	70
Costs per 1rouble of commercial output	35,39
Prime cost of annual production output, thousand roubles	6431,74
Profit, thousand roubles	1251,38
Estimate of cost of construction, thousand roubles	7707

1	2
Including:	
building and construction works	4065,37
equipment	2870,93
other expenses	770,7
Annual expenditure	
main and additional materials, thousand roubles	3478
electric power, thousands kWh	2482,26
heat energy, Gkal	37589,3
compressed air, thousand m^3	413
water, thousand m^3	39,74
Pay-back period, years	6,2

3. AUTOMATIC PRODUCTION LINES FOR REINFORCEMENT WORKS

Implementation of continuous reinforcing of reinforced concrete structures opens principally new opportunities of complex mechanization and automation. At the same time, it reduces labour consumption, consumption of reinforcement steel, provides more efficient use of production areas [3, 4].

Automatic installation of continuous reinforcing of inner wall panels is designed by NIIZhB of USSR Gosstroy jointly with Tallinn branch of SKTB Stroyindustriya of Minsevzapstroy of USSR.

Main technical properties of the installation:

Range of reinforcement, mm	
by length	6000
"by width"	3000
"by thickness"	150
Diameter of reinforcement wire, mm	4
Speed of delivery of reinforcement wire, meters per minute	35
Speed of moving of tail spindle through length and through height of reinforced product, meters per minute	29,83
Tension force of reinforcement wire, T	490
Installed capacity, kW	24,7
Sizes, mm	
length	7400
width	4100
height	5300
Total weight of installation, kg	5300

The installation is made stationary (Fig.2), as two frames (right and left), along the frames in longitudinal direction on all length of the form, trolleys with spindles are being moved. The spindles themselves are made with turn rollers and mechanisms of change of their length, fixed on the pitch of winding.

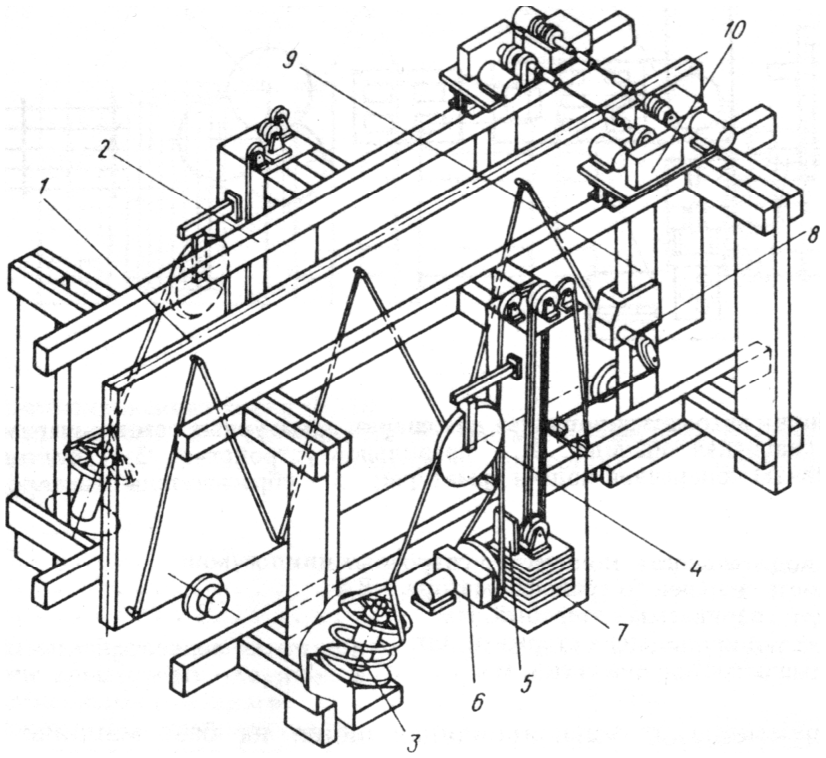

Fig. 2. Installation of continuous reinforcing of panels on cassette-conveyor line: 1 - mould; 2 - upper guide beam; 3 - coil-unwinding machine; 4 -lead block; 5 - stops; 6 - axis drive system; 7 - wire bridling installation; 8 - tail spindle; 9 - traverse beam; 10 - traverse beam move mechanism.

Machine allows to perform automatically of reinforcement winding on the stops of vertical moulds simultaneously from two sides. Winding is performed in the following sequence. Vertical mould is being rolled to the forming post between two frames, and is being fixed in such position. Reinforcement from the coil (wire or strand) is being passed through the system of guide rollers of the tension device and spindle. It's end is being fixed on one of stops of the form. The mentioned operation is being performed simultaneously from two sides of vertical mould, and the cones of reinforcement are being fixed on coaxial stops. Then, there begins winding of reinforcement on stops during movement of trolleys in frames horizontally, and spindles vertically. After spindles reach upper or lower extreme position, drive of horizontal movement is being deactivated, and turn of the roller takes place, reinforcement passes around the stop, after that drive is being activated, and stretching-out takes place to the next stop. So, the process is being repeated to the end of winding from both sides of the form of lower lines of reinforcing cages. For winding of the next reinforcement layer, the length of spindle is being reduced by pitch, and is

being fixed with stopper. Then the operation is being repeated in the above-mentioned sequence to the end of winding of outer layers of reinforcement cages. After that, the ends of reinforcement wires are being fixed on the extreme coaxial stops, and are being cut off.

Especially efficient is the use of the mentioned installations for making floor panels, because they provide opportunity of preliminary tension of reinforcement in the process of winding. As a whole, the use of continuous reinforcement will make it possible to reduce labour intensiveness of reinforcement works 2-2,5 times, and consumption of reinforcement stell by 20-35 %.

A whole range of automatic lines and complexes for making reinforcement elements are designed by NPTO Belstroynauka of Belarusian Soviet Socialist Republic Gosstroy.

Automatic line ML 90 is designed for electric contact welding of fine-meshed net from reinforcement wire of classes V-1 and Vr-1 with delivery of reinforcement from coils. The line, implemented on the factory of SZhB №3 of Belarusian Construction Ministry, consists of modernized welding machine, strengthening device, reel-stands, mechanism of transverse delivery of reinforcement, kicker-piler (Fig. 3).

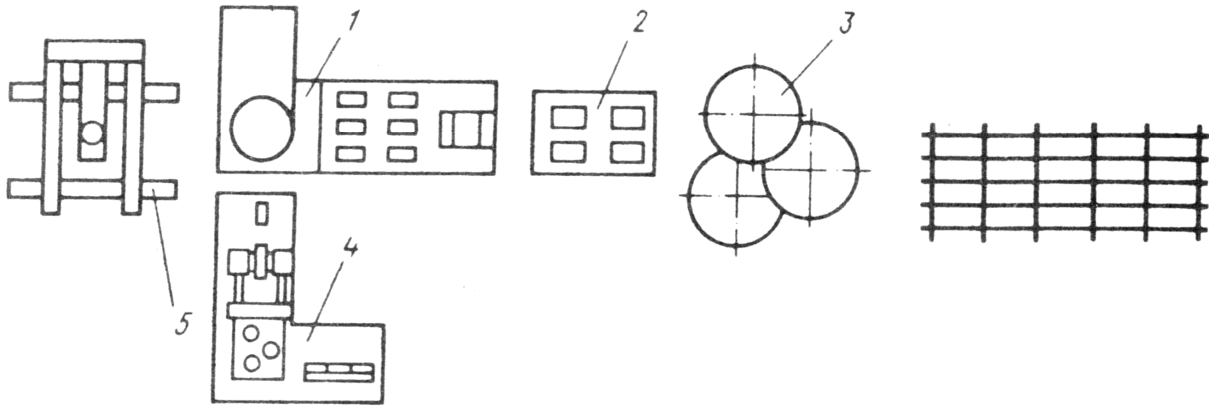

Fig. 3. Automatic line for welding of bar mat reinforcement with pitch 50 mm: 1 - welding machine; 2 - straightening device; 3 – reel stand; 4 - mechanism for cross-feeding of reinforcement; 5 - dropper-packager.

The line may operate in checkout and automatic modes
Productivity, amount of welding cycles per minute ……18
Power capacity of welding transformer, kWa……131
Diameter of welded bars, mm……..……3 - 5

Amount of longitudinal bars…….....6
Maximum width of the net, mm…….370

Automated line based on MTMS - 10x35 machine is also a perspective solution; it is designated for making nets with automatic feeding of both longitudinal and transverse reinforcement from packets (Fig. 4).

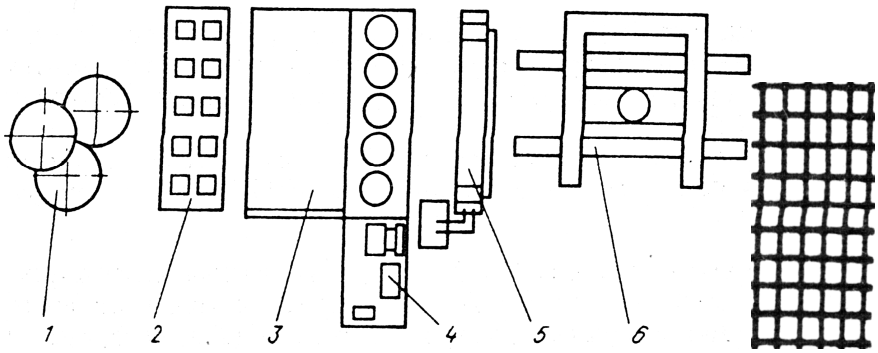

Fig. 4. Automated line based on machine MTMS-10x35:
1- reel stands; 2- straightening devices; 3 - welding machine MTMS-10x35; 4 - mechanism for cross-feeding; 5 - scissors for net cutting; 6 -receiving and packaging device.

Line ML 94 consists of reel-stands, straightening devices, modernized welding machine MTMS - 10x35, mechanism of transverse delivery, scissors for net cutting, take-up-piling device. The output of the line with pitch of 200 mm is 12 m per minute.

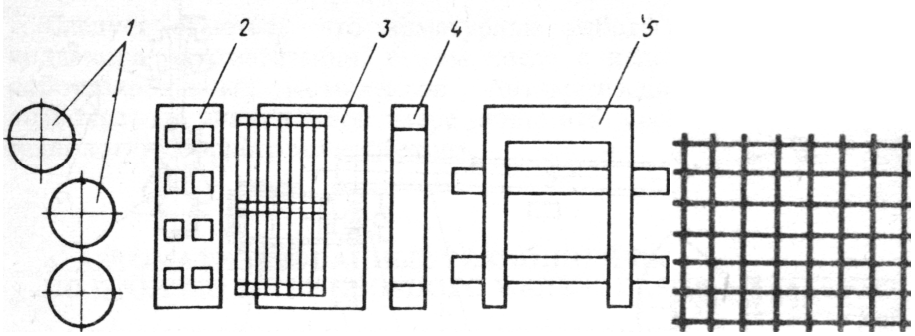

Fig.5. Automated line LS-10:
1 - reel stand; 2 - straightening mechanism; 3 - modernized welding machine MTMS-10x35; 4 - scissors for net cutting; 5 - receiving and packaging device.

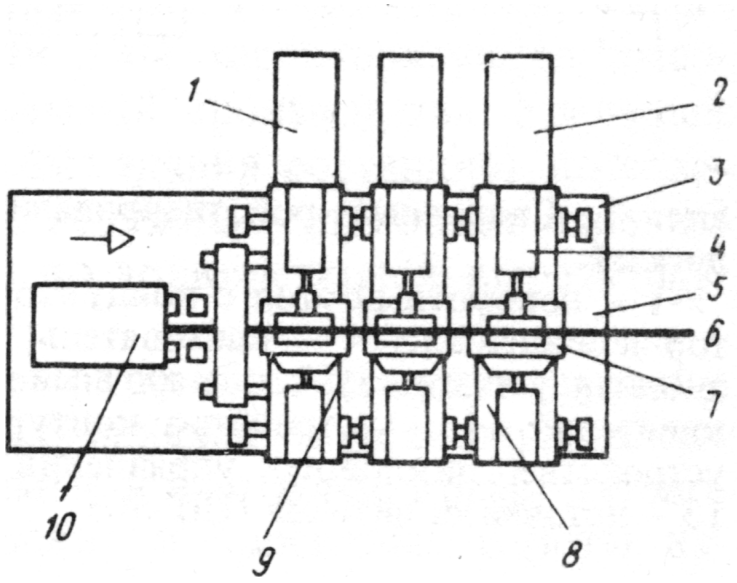

Fig.6. Automated line for making reinforcement bars with double anchor head: 1 - clutch; 2 - clutch pneumocylinder; 3 - leading grip; 4 - support; 5 - slide; 6 - wire; 7 - jaws; 8 - electroheating; 9 - upsetting heads; 10 - pneumocylinder for upsetting.

Automatic line LS-10 provides increase of efficiency of making reinforcement cages for multi-void reinforced concrete floor plates (Fig.5). The line may perform in training and automatic modes, output of the line with mesh size 125x125 mm reaches 2,5 meters per minute.

Automatic line for making reinforcement bars with twin anchor heads is designed by SKB of Glavstroyprom of Mintransstroy of USSR, and is installed on Tolmachevo Plant of Reinforcement concrete structures in Leningrad region (Fig.6). The line with output 140 m per hour is a highly-mechanized complex performing preparing of bars, their putting into upsetting devices, electric heating, upsetting of anchor heads, and transposition of ready bars into the storage device. Use of reinforcement bars with twin anchor heads in reinforced concrete structures makes it possible to save up to 40 kg of cement per 1 m^3 of product. Annual economic efficiency from the implementation of the line is about 20 thousand roubles. Multi-reworking and labour-consuming moment in the technology of precast concrete is production of embedded fittings. Development of complex production lines with high level of automation is rather important task. Welding robotized complex for production of embedded fittings, developed by experimental-mechanical factory and NIL FHMM, and TP Glavmospromstroymaterialy.

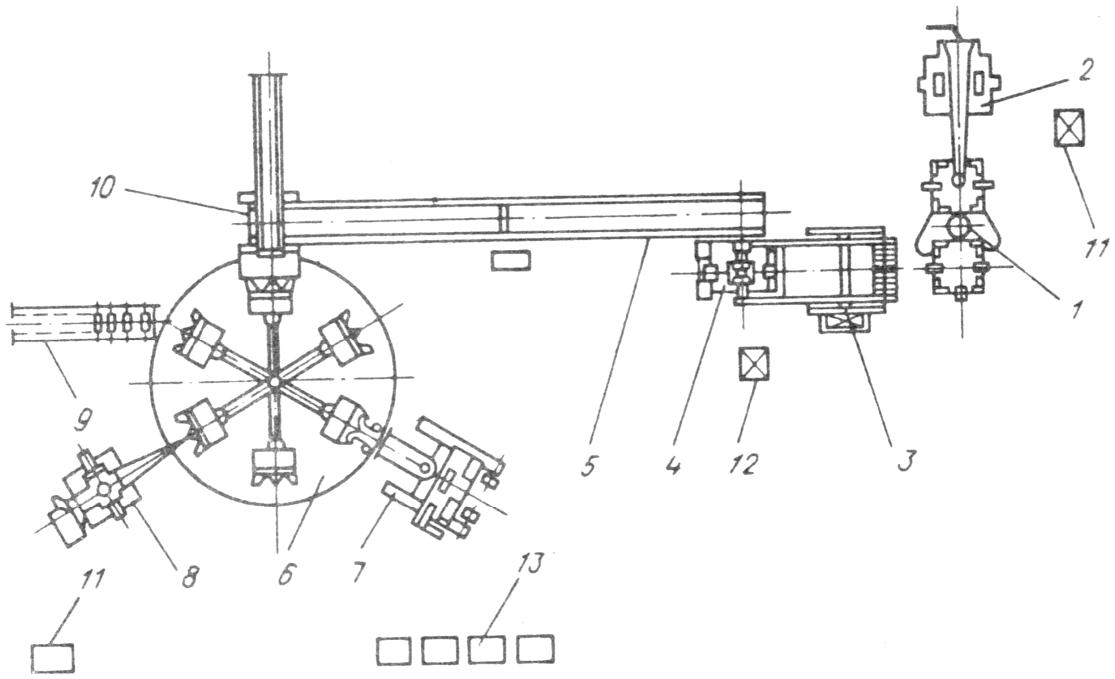

Fig.7. Welding robotized complex for making lay-in components: 1 – turn table with conductors; 2, 8 — welding robot; 3 – pick-and-place manipulator; 4 – turn-over device; 5 – roller conveyer; 6 – rotor positioning device; 7 – four-point welding automatic machine; 9 – roller conveyer; 10 - shifter; 11 – device for path control of welding robot; 12 – device for cyclical control of group of transport-feed devices; 13 – power sources.

The complex includes site of preliminary assembly, group of transport-delivery devices, and site of final welding (Fig.7). The site of preliminary assembly includes turn table with two assembly conductors, and robot-welder. Group of transport-delivery devices consists of pick-and-place manipulator, turn-over device, and roller conveyer with shifter. Site of final welding consists of 6-position rotor installation with turn grippers on each position, 4-point welding automatic device, and welding robot. Unloading and delivery of ready products is being performed with roller conveyer. Use of the complex provides reduction of labour costs 3 times, improvement of labour conditions.

It should be mentioned that reinforcement works may be automated to a considerable degree, including use of various robotized complexes. Automation of reinforcement works makes it possible to significantly increase level of automation in the technology of precast concrete.

4. AUTOMATIC TECHNOLOGICAL LINES FOR PRODUCTION OF PRECAST CONCRETE

4.1. Technological lines for production of outer wall panels

The most important element in civil construction, and, first of all, in precast large-panel construction, is outer wall panels. They require high strength, heating, sound insulation indices, as well as durability and atmosphere-resistant. They are characterized by high labour consumption, significant volumes of production. Specific weight of outer wall panels in total volume of building, amounts, in costs, about 16-18 %. Besides this, outer wall panels require high architectural expressiveness [4].

These are the factors which determine great variety of existing types of outer wall panels and production lines for their making. The performed scientific and research works are aimed at, first of all, the improvement of the level of mechanization and automation of the production of high-quality outer wall panels. Production lines for making outer wall panels may be conditionally divided on several groups, according to their construction, technology and other criteria:

Lines with longitudinal and transverse placement of forms-trolleys. Lines with transverse placement make it possible to increase number of specialized posts, what allows to provide regular rhythm of work of all conveyor, it is especially important for high-capacity factories. Technological lines with transverse placement of mould have become rather widely used in Russia.

One-branch and two-branch conveyor lines. The presence of the second branch of forming conveyor makes it possible to increase the number of specialized forming posts, but, in this case, additional equipment is necessary, namely, the transfer cars. Two-branch line may be installed only in span 24 meter wide.

Production lines with various types of chambers of heat-and-moisture treatment: two- and three-level with carrying-out beyond the production department etc. The most widespread lines are outer wall panel lines, developed by the Instututes Giprostrommash, and GPI №2. Conveyor lines for making outer walls and floor plates are designed for newly-built and reconstructed enterprises of precast large-panel construction of average (100-140 thousand m^2), and large capacity (180-220 thousand m^2 of total area per year). The main technical-economical indices of four standard projects of production lines are given in the Table 4, and layouts of technological configuration is shown on the Fig.8. The projects are

developed in two versions: with thermal treatment of reinforced concrete products in underground and surface one-level slit type cameras.

As a new main technological equipment, there was used new serial equipment, made by the Minstroydormash factories.

The main distinction of conveyor lines for high capacity factories, from lines for average capacity factories is the presence of two strings of posts of forming and finishing. This makes it possible to more completely use of posts of removal of formwork, and preparing of forms to concreting, and provide on the posts of forming and finishing the work, duration of which is equal to double rhythm of the work of the line. On the line for average capacity factories, there is no need for branching of posts, because the time given for work on forming and finishing posts is enough for fulfilling these operations.

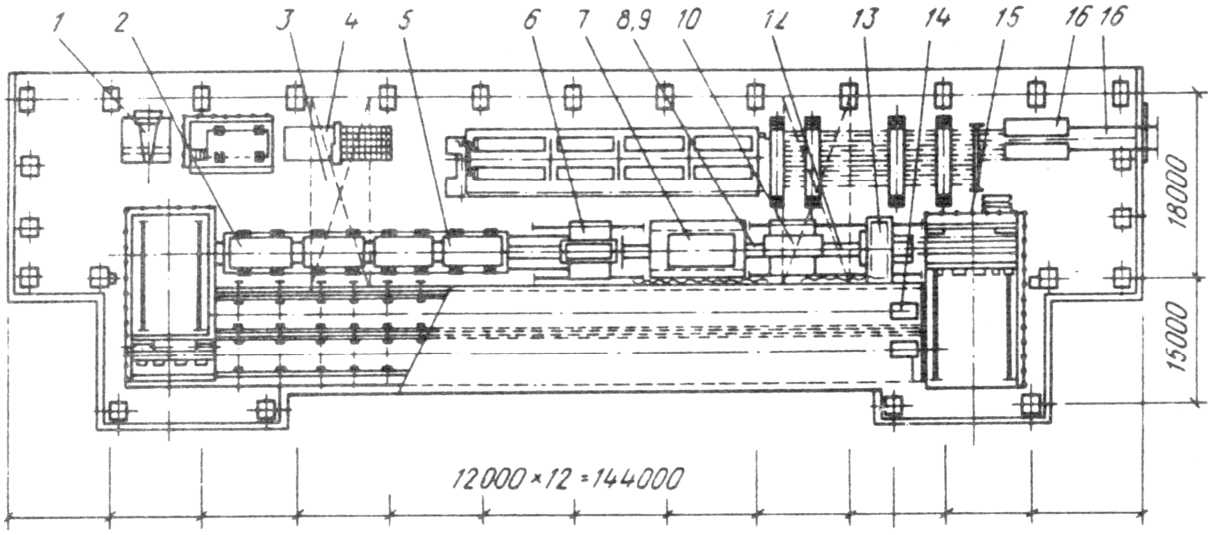

Fig.8. Technological line for making outer wall panels with surface slit type cameras: 1 - cantilever crane; 2 - turn-over device SMZh-439; 3 - overhead crane; 4 - mechanism of opening and closing of boards of SMZh-453; 5 - finishing line; 6 - concrete paver SMZh-166B; 7 - sound-insulating hull SMZh-653; 8-vibratory plate SMZh-B; 9 - suspended rails SMZh-458;10 – concrete paver SMZh-528; 11 - drive SMZh-300B A-17; 12 - sections for installation of products; 13 - finishing machine SMZh-461;14 - equipment for slit type cameras SMZh-445;15 - transfer car SMZh-444-02; 16 - self-propelling car SMZh-151.

Table 4

Indices	For making one-layer outer wall panels in factories		For making unstressed floor panels in factories	
	average capacity (t.p. 409-013-12.83)	high capacity (t.p. 409-013.23.83)	average capacity (t.p. 409-013.17.83)	high capacity (t.p.409-013.24.84)
Capacity of factories of precast large-panel construction, thousand m^2/year	140	220	140	220
Prime cost, 1m^2/year	57,2/57	42,26/42	54,16/54,01	41,86/41,81
Cost, thousand roubles:				
of building and construction works	251,5/224,8	287/257,7	551,2/473,9	544,5/449,6
of equipment	502,5/471,2	373,8/347,3	651,4/623,6	510,6/481
Heat consumption for technological needs, Gcal/h	0,915	0,68	1,37	0,96
Installed capacity, kW	797,7/753,7	436,4/393,9	989,7/945,7	664/620
Air consumption, m^3/minute	7,2	5,7	7,4	5,3
Total area, m^2	2592/4272	2592/4272	3744/5627	3744/6527
Number of posts,	9	15	9	15
including duplicated	-	4	-	4
Number of forms:				
on posts	9	15	9	15
in the chamber of heat treatment	24	42	24	42
Rhythm of workers occupied in the shift	12	16	8	14
Rhythm of line operation, minutes	26	16,5	23	11,3

Remarks:
1. Estimated cost for factories of average capacity in prices actual before 1984.
2. Numerator shows indices for lines with underground, and denominator, for lines with surface slit type cameras of heat treatment of products.

Transfer car SMZh-444 has design of more high degree of reliability and higher push force than previously made transfer car 2693/2; pusher works in both sides. Elevator SMZh-438 simultaneously operates as descender (bringer-down), what reduces the number of types of the used equipment. The elevator, transfer car and equipment of slit-type cameras SMZh-445, construction of which is also improved in comparison with previously made, may operate jointly in semi-automatic mode. One device is used for opening and closing of boards, SMZh-453, instead of previously used two devices, and its design is more reliable.

Design of lifting rails SMZh-458 is simplified, what increased their reliability. Concrete paver SMZh-528 is designated for paving mortar on upper surface of product, what contributes to improvement of quality of finishing. Finishing machine SMZh-461 for smoothing surfaces of freshly-formed product has two end-effectors: roller and disk. For getting high quality of surface, and reduction of machine components wear, the design of smoothing roller is equipped with special device, the use of which prevents roller from transfer through boards during the finishing process, which keeps it from wear. This device also provides control of pressure of disk on concrete. Serial production of finishing machine has started since 1985.

Reduction of range of types, and increase of reliability of equipment of conveyor lines allows to improve maintenance service of lines, reduce necessary number and range of types of spare parts, what makes positive effect on lines operation. For improving labour conditions and noise reduction from working vibratory plates, sound insulating hulls have been installed on the lines. The hull is spatial frame, dressed from the inside with sound-absorbing material, and having on butt ends elevating gates for passing of form. For performing maintenance works hull may be removed by overhead crane on average capacity lines; there was provided opportunity of transfer to neighbouring post on the large capacity lines.

Heat treating of reinforced concrete products is performed in chambers of continuous action, what makes it possible to reduce steam consumption, on average, by 25%. Heat treatment is provided by indirect stream (through registers), and hot air. Hot air makes dry the panels of

outside walls to standard (normative) humidity, what improves their quality, and makes it possible to perform their high-quality further finishing. The process of heat treatment of products in slit-type cameras is automated.

On lines for making one-layer outside walls, forming of products is provided "face down". In this method of forming, joiner's blocks are being installed in reinforced concrete products on the line. In this case, finishing of face surface of panel may be made with ceramic tile, revealing of mortar, painting with water-emulsion and polymer-cement compositions, or powdering with fine-grained powder on polymer-cement basis with use of finishing line SMZh-463-468.

Typical lines for factories of average capacity are placed in technological span with size 18x144 m, lines for factories of large capacity, in span with size 24x156 m. In spans, there are provided posts of restringing of forms, equipped with mobile cantilever crane with load carrying capacity 3,2 tons. Configuration of typical conveyor lines in technological projects provides an opportunity for each case, to use various types of delivery of concrete mixture and reinforcement products to the places of their consumption, what especially important in reconstruction of working enterprises.

The horizontal-close line of Pavlodar DSK is characterized by high level of mechanization. The line is equipped with machinery for performing complex of operations; cleaning and lubrication of forms, closing boards, putting base course, installation of reinforcement and joinery products, pouring and compaction of concrete mixture, smoothing of surface, removal of flaws and quality control of panel.

During the use of low-frequency stroke-vibrational installations, there is no necessity in installation of sound-insulating hulls.

In technological line of conveyor, 41 forms of trolleys is used. For heat processing of structure, three slit-type cameras, 4,5 m in width, are equipped with electric heating. Transfer of forms-trolleys on conveyor is made by pushing machine. For transfer of trolleys from conveyor to slit-type cameras and from them to conveyor line, two transfer-cars are designated. For opening boards of forms-trolleys, and for their fixation in closed position, the devices SMZh 300 2A and SMZh 300 4A are used. Heat treatment of products with electric heater is performed during 6-8 hours, during the process, turnover ratio of forms increases, what provides opportunity to significantly reduce the stock of forms and expenses on their operation.

On Kursk DSK, there have been implemented three inclined-closed conveyor lines for making reinforced concrete products, designed and made by EKB of Minuralsibstroy. Each of the lines include forming conveyor, two trolleys-descenders (bringers-down), and two-three slit-type cameras of heat treatment. In its turn, the forming conveyor includes two drives-pushers, trowel machine, concrete paver, mortar paver, turn-over device, mechanism of opening and closing of boards, vibratory plates, hydrostations with control equipment.

Drain-pan-trolley with thermally-treated product, placed on one of descenders (bringers-down), is being gripped by the drive of conveyor, and is drawn off to the first post of forming conveyor. On the first post, boards are opening, then the product is being transferred to the second post, turnover post, where pick-up of the ready product takes place; the next posts are cleaning and lubrication of forms, closing boards and laying of reinforcement, pouring of mortar and concrete, finishing of surface. After performing all operations, drain-pan-trolley is being pushed to the trolley-descender (bringer-down), which, descending, stops before one of chambers.

Removal of drain-pan from trolley, and pushing of all drain-pans, placed in chambers, is performed with drives, placed in each chamber. Depending on the number of slit-type chambers, the output of conveyor oscillates: two chambers, 125 thousands m^2, three chambers, to 160 thousand m^2 of floor space in terms of products of precast large-panel construction.

Amount of posts of forming conveyor may change from 6 to 13. Pitch of posts is regulated from 7 to 9,2 m due to adjustment of screw shackles. The adjustable pitch of forming conveyor makes it possible to place lint in production departments of various length, work with typical and other types of drain pans.

Later on, the construction of the line was modernized. All this made it possible to improve specification figures of conveyor line for production of outer wall panels designed by EKB of the USSR Minuralsibstroy. Its parameters are given in the table below:

Maximum overall dimensions of produced reinforced concrete products, m	7,2x3,1x0,4
Adjustable pitch of posts	7,6-9 (8-9,2)
Pitch of posts of line during use of typical drain pan, m	8,85
Speed of movement of forms on forming conveyor, m per minute	6

Speed of movement of forms in slit-type chambers, m per minute	6
Speed of movement of trolleys-descenders, meters per minute	4,8
Tractive effort of pusher № 1, N	900000
Tractive effort of pusher № 3, H	15000
Tractive effort during elevating of descender, N	80000
Total installed capacity of non-standardized part of equipment, kW	95,5
Mass of non-standardized part of equipment, kg	53000

The use of such line is efficient in reconstruction of operating enterprises. VNIIZhelezobeton, with the purpose of improving technical parameters, and increase of efficiency of conveyor lines, with account of experience of existing conveyors, developed two-branch conveyor lines in new configuration. Conveyor line is equipped with forms-trolleys, technological and transport equipment, and consists of two branches of forming conveyor, form chamber, and two-branch underground chamber of heat treatment, partially placed beyond the building. Chamber is linked with forming line with elevator and descender. Transmitting device which is placed in butt end of chamber, has a drive, placed in special section, isolated from heat environment, which improves conditions of operations, and increases reliability of work of the drive. In the butt end of the line, opposite to chamber of heat treatment, forming branches are linked with transmission device, placed in the area of reinforcement department, where post of installing of reinforcement cages is equipped. Preparation and finishing parts of forming branches are placed near each other, and are served by elevating-transporting device of manipulator type. Replacement of forming chamber is used for intermediate storage of embrasure-makers, liners, and joinery blocks.

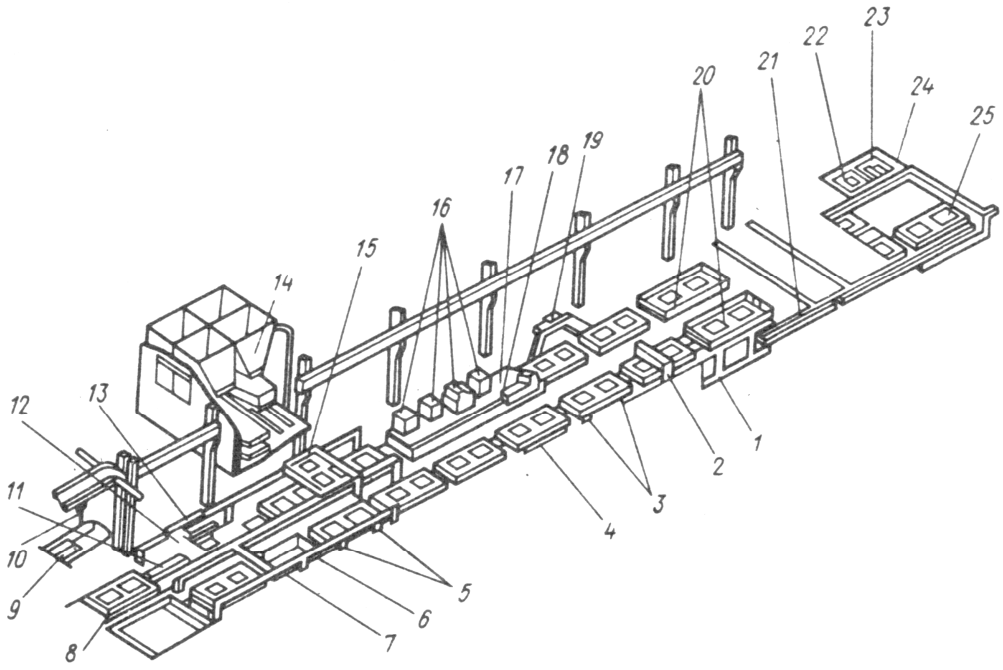

Fig. 9. Two-branch conveyor line:
1 - moulds; 2 – spackling machine; 3 – mechanism for side opening; 4 – turn-over device; 5 – mechanism for side closing; 6 - viaduct; 7 – mortar-laying device of the lower layer; 8 - deliverer; 9 – reinforcement cage; 10 - crane; 11 - pushers; 12 – vibratory plate; 13 – concrete-paver; 14 – gallery of concrete-mixing unit; 15 – concrete-paver of the upper layer; 16 – depository of components; 17 - premixer; 18 – guide rail; 19 – hoisting-and-handling mechanism; 20 – elevator-descender; 21 - Heat and moisture processing chamber; 22 - deliverer; 23 – drive; 24 – isolated module; 25 - bogie

Posts of mortar and concrete mixture pouring are placed in the area of gallery of local concrete-mixing unit; mortar-pavers and concrete-pavers are moving on dual estacade. Such configuration of conveyor reduces the length of routes of technological flows; laying of reinforcement into the form in the area of reinforcement department excludes transportation and near-post storaging of cages in forming department, concrete mixture and mortar are being delivered to the pavers directly from local concrete-mixing unit, what excludes transportation of concrete mixture in the department and loss of time for waiting of loading.

Placement of posts of finishing of products near posts of preparation of forms makes it possible to carry out maintenance works with manipulator, which delivers components from storage placed in prechamber, and embrasure-makers, removed from forms on posts of finishing, are given on the site of preparing forms. This reduces amount of form equipment available in circulation.

The first post of finishing conveyor is placed near the post of stripping of formwork, so the length of route of movement of ready products picked up from conveyor, is minimum. Suspended forming equipment made it possible to place conveyor in span 18 meters in length. It is also possible to use on-floor equipment. In this case, it is reasonable to place conveyor in span 24 meters wide.

Besides Sverdlovsk factory, two-branch conveyors are used also on precast large-panel factories under construction in Dnepropetrovsk, Krivoy Rog etc. Two-branch line in new configuration is launched on precast large-panel factory in Kremenchug (Fig. 9).

Use of two-branch configuration and reduction of routes of flows made it possible to decrease the length of span in Dnepropetrovsk factory to 132 m, and in certain conditions, it is possible to reduce its length to 120 m. Opportunigy of placement of such conveyor in span 18 meters length makes it possible to use it for reconstruction of operating enterprises.

In the Table 5, there are given comparative technical-economical indices of conveyor lines on production of outer wall panels.

Table 5

Indices	Two-branch line	Slanting-closed conveyor	Typical project conveyor 409-13-8
Annual output, thousand meters^3	46,2	46,2	46,2
Specific metal consumption, kg/m^3	13,3	14,0	14,4
Labour consumption, man-hour/m^3	1,6	2,2	2,2
Prime cost of processing (forming), roubles/m^3	8,4	9,0	9,4
Specific capital investments, roubles/m^3	14,0	14,6	17,1
Overhead costs, roubles/m^3	10,5	11,2	12,0

Mastering of branch conveyor lines makes it possible to reduce labour consumption, specific metal consumption, prime cost of production, and specific capital investments. Estimated annual economical efficiency from implementation of one conveyor is 50-70 thousand roubles.

According to проектно-сметной документации, developed by PKTB of Minpromstroy of BSSR, on Gomel DSK there was built production department for making outer wall panels of series 152 for 5- and 9-storey precast large-panel residential buildings. Production technology of panels designed on the basis of study and summarizing of advanced experience of Russian factories of precast large-panel construction, and designated for high level of mechanization and automation of technological processes.

In production department 156 meters in length, two two-level conveyor lines are placed, and two conveyors for finishing panels to complete readiness and putting to the finished product storage. The project is developed with account of the following requirements: technological equipment designed for use of forms with unified drain pan; provided readjustment and change of forms in technological flow without breaking rhythm of its operation; sizes of forming surfaces of drain pans and main technological equipment makes it possible to make products with maximum overall sizes 7x3 m.

Conveyor belt is vertical-closed two-level line of forms-trolleys, sequentially moving along technological posts with aid of two pushers. In the first level, 11 technological posts are placed, on which the following operations are being made: pick-up of clamping shield, opening of locks of transverse and longitudinal boards of form-trolley; turn-over of form-trolley and pick-up of product; back turn-over, cleaning of drain pan and boards; closing boards, lubrication of form; installation of liners and reinforcement of lower layer of concrete; pouring of heavy concrete into the form; smoothing, vibration compaction and check of thickness of its layer; putting into the form of packets of heater, reinforcement of upper layer of concrete; pour into forms of light concrete into form, compaction; pouring of upper layer of mortar, smoothing; making surface of concrete; stand-up of products.

In the second level, slit-type chamber of continuous action is placed, for 12 forms-trolleys, where products pass heat treatment under temperature 85 - 95°C by the following mode: 1 hour - stand-up, 2,5 hours - increase of temperature, 5,3 hours - isothermal heating, 1 hour - cooling. Increase of temperature and isothermal heating for all products is made by indirect stream. Efficient insulation of slit-type cameras is provided. Transportation line of conveyor consists of elevator-descender and two pushers, which provide rhythmical movement of forms-trolleys. Control over the line is performed from the central control post, placed near forming post.

In comparison with the now operating lines, the ling of making of outer wall panels has the following advantages:

- complete mechanization of technological processes;
- on each line of forming, two vibratory plates are installed, what made it possible to increase rhythm of conveyor operation, and improve quality of products;
- form-trolley gets from descender of elevator directly on the first or the second level, as a result, there is no more necessity in transfer car;
- thermal processing of products is carried out in thermal-insulating slit-type cameras with automatic regulation of steaming mode;
- finishing conveyor is made with exit to the finished product storage, what excluded necessity of using crane for pick-up and installation of products on self-propelled trolley (traditional technology).

Main technical-economical indices of conveyor line: annual production output, 39000 m^3; estimated cost of construction, 2892 thousand roubles; pay-back period, 4,2 years; reduction of labour consumption, 2800 man-hours; annual economic efficiency, 78 thousand roubles.

Design configuration solutions, orientated for minimizing the mentioned costs in production of wall expanded clay - concrete panels of industrial buildings in conditions of the existing average shortened span 18x120 meters in size, implemented in the production line, designed by Minsk branch of KTB Stroyindustria, and used in the factory SZhB-11 in Svetlogorsk, Gomel region.

The line is designated for making wall panels 200 and 240 mm in thickness, 1.432-5 series, issue 1. If necessary, the line may be used for making other types of products. The line is vertically-closed two-level conveyor with transverse placement of forms-trolleys. On the upper level, technological posts with necessary equipment are placed, on the lower level, slit-type chamber for thermal treatment. In the end part of the chamber, there are pits for elevator and descender.

Conveyor includes the following technological posts: pick-up of products from form-trolley, cleaning and lubrication of forms-trolleys, putting tile on the mirror of drain pan, putting of volumetric reinforcement cages, closing of longitudinal and butt-end boards of form, pouring and compacting of the lower level of mortar and expanded clay concrete, pouring and compacting of the upper layer of mortar, stand-up of products, finishing of the upper surface of panels.

Expanded clay - concrete wall panels on conveyor belt are made in impulse mode with rhythm of movement of forms-trolleys from post to the post 20-28 minutes.

Form-trolley after thermal treatment is being put on the platform of elevator. During elevation of form, levers of its locks are rest against four rollers, installed on the supports of elevator, and open at first the locks of the form, and then, its butt-end boards. Longitudinal boards of form are opened after the platform of elevator is replaced on the upper level of conveyor. For this purpose, platform is equipped with two pairs of stops.

During moving of form, which is imparted by the elevator pusher mechanism to the side, opposite from conveyor, levers of joints run against stationary stops, and one longitudinal board opens. Then, during pushing of form from the platform of elevator on the first post of the upper level of conveyor, second pair of pendulous stops snaps into action, and the second longitudinal board opens. So, use of movement of elevator platform and its pusher for opening locks and boards of form, made it possible to exclude one technological post of upper level and special mechanism of board opening.

Form-trolley with products is delivered by conveyor to the pick-up from form post. For pick-up of products, special device is used, which is being suspended on the hook of typical traverse beam SMZh-289A. Gripping organ is a welded body consisting of two sides united between each other by plates. Inside the body there is bushing with spring-backed seal. On one of the sides, bushing is installed with spring-backed fixing pin, serving for slinging product into the loop. By the elastic lead, the pin is being returned to the initial position.

The stop with the aid of axis jointly attached to the body, and serves for prevention of spalling of edges of panel during its transfer from horizontal to vertical position. During the elevation of the panel, the loop goes between sides of body of gripping organ, with further pressing on the handle, fixing device runs against the loop and compresses the spring, providing opportunity for fixing pin to make slinging. The stop is being descended on the rib of the panel and elevates it. Deslinging of the panel is made by elastic lead. In this process, fixing pin returns to the initial position, and fixing device again covers the opening. Load carrying capacity of the device is 3 tons, mass is 14 kg.

The panel with removed formworks by the overhead crane is delivered to the cleaning machine designed in the factory SZhB-11. Powerful shaft of the machine is being put close to the panel, this shaft, rotating and moving along the panel, removes from the surface, finished with tile, the glued paper. Then panels are being loaded to self-propelled

trolley SMZh-151, and delivered to the finished product storage. Panels are being transported in vertical position, fastened in cassette supports, which provide safety of facial surfaces of products. If any flaw is detected, the panel is being delivered to the post of backfitting. In winter, panels aged in the production department during 8 hours.

Form-trolley free from product is moved by conveyor to the post of mechanized cleaning and lubrication of forms. Cleaned and lubricated form through conveyor is delivered to the post of laying of decorative tile. On the next post, into the form, by overhead crane, spatial reinforcement cages with embedded fittings are installed. At the same place is the mechanism of closing boards of form, which consists of units of closing of longitudinal and butt-end boards, and hydrosystem, including hydraulic station SMZh-346.

Unit of closing boards has hydrocylinder, mounting brackets of hydrocylinder and pivot rod. During the switching on of the mechanism, hydrocylinders turn rods, which rest by the rollers against the boards of forms, and close firstly, longitudinal, and then, butt-end boards, linked with rim locks, which carry out fixation and holding boards in operational condition. After closing of boards, levers of the mechanism automatically return to the initial position.

Full automation of boards and locks opening on the elevator-descender as well as mechanization of boards and locks fixing on a special platform are provided by the structural design of a lock. The lock consists of the double-arm lever the upper shoulder which has a lug. On the lengthway board of the mould there is welded a boss-arrangement. Between the lower shoulder of the double-arm lever and a wall of the header there is a pressure spring. A block stop is fixed on the bottom plate by means of the cheeks. In a closed position the headers are restrained by the lug which catches the boss-arrangement welded on a lengthway board. The double-arm lever is restrained by the pressure spring from any spontaneous opening during heating operations and movement of moulds in the camera and from a platform.

For output of a gear tooth and the opening of butt-end side it's necessary, by device for stripping formwork to click on the T-shaped ledge in the process of lifting on platform of lift and contact of the protrusion with the abutments mounted on the lift (in the usual lines required a simple mechanism of direct action, such as a hydraulic cylinder, mounted on the post of removal of formwork). Thus, two-shoulder lever, turning on its axis, compresses the spring and leads out of gripping with the lug, the tooth of upper shoulder of two-shoulder lever. Further impact to the T-shaped

protrusion, the lower shoulder rests on the stop of the drain-pan and opens the butt-end board. Then, the form-trolley is delivered on the forming post, where lower layer of mortar and a layer of expanded clay concrete are poured and compacted. The post is equipped with a vibratory plate SMZh-200A, by lifting rails it is lowered along the longitudinal axis of the form, puts a layer of mortar and expanded clay concrete, which, by turns, are sealed by vibratory plate.

In CMZh-200A vibratory plate, distances changed between vibro-blocks for placing the lifting rail and the configuring of the forming of the post in line. Lifting rails are composed of the following main units: carriages, platforms, brackets, hydrocylinders, and pump stations. The carriage is a welded metal construction with six rollers, four of which serve to move along horizontal rails and two for raising and lowering the platform. The carriage is driven by a hydraulic cylinder. Platform is welded steel construction with four rollers for its vertical movement on the guide rails of bracket and four wedges for supporting on the rollers of the carriages. The platform is raised and lowered on the principle of work of wedge devices.

When moving the carriages along the guide rails, the rollers mounted on them, bump on the inclined surfaces of the wedges of the platform and raise it together with placed on the post form-trolley, tearing it away from the blocks of vibratory plate. In this process, the platform rollers roll along the guide rails of brackets. The brackets do not allow the platform to move in a horizontal plane. When moving the sliders in the reverse direction, the rollers of the carriages descend from the platform wedges and it descends. Form-trolley in this process hovers on the blocks of vibratory plate. The end positions of the carriages are fixed by limit switches.

To pass through the openings (slits) in the rails of gauge of the concrete paver, designed for the passage of the wheels of the form-trolleys and rails for moving the pushers of the conveyor, a typical concrete paver is equipped with two additional leading and two additional driven wheels, and the distance between the axes of the main and additional wheels is more than gaps in the rails that allows, during the travel, to this or that wheels to be in contact with the rail head.

After placing and compaction of concrete on the vibratory plate, the concrete paver goes out for loading, and form-trolley with formed products, by lifting rails rises to the level of transportation, and by the conveyor moves to the position of paving of the upper layer of the mortar. Here, the concrete paver CMZh-162, passing along the form, pours a layer of mortar 20 mm thick and compacts it with smoothing beam. After

placement and compaction of a layer of the mortar, the paver is moved to loading, performed in this line by the belt conveyors, and form-trolley moves to the posts of ageing and surface finish of the panels by disc of trowel machine. In addition, on these posts, sides of forms are cleaned from the remnants of concrete and mortar.

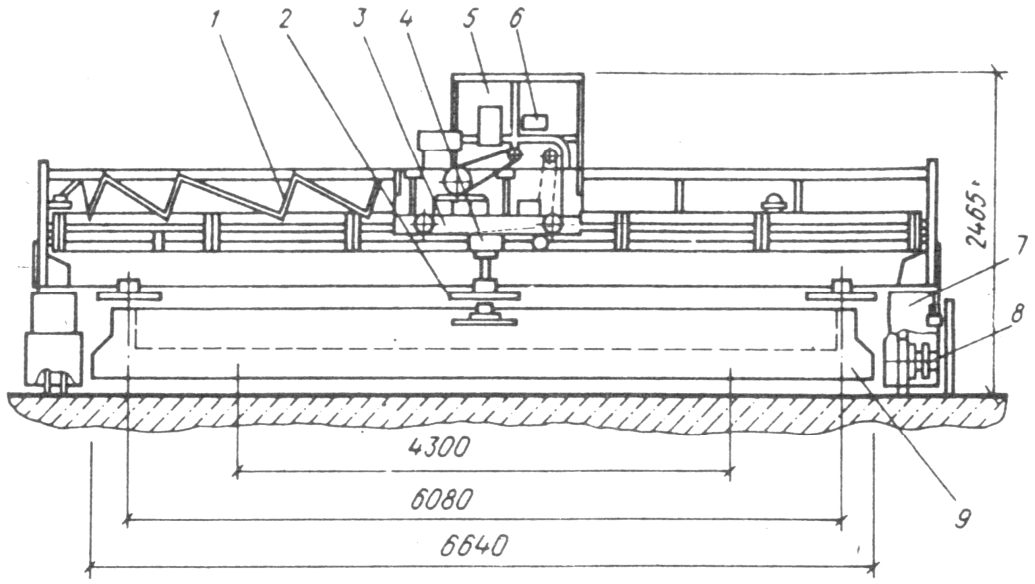

Fig. 10. Rubbing machine:
1 - barrier; 2 - disk; 3 – bogie; 4 – rubbing head; 5 – place for controller; 6 – control panel; 7 - portal; 8 – travel drive of portal; 9 – mould.

Trowel machine is used for final finishing of the outer surface of the wall panels of industrial buildings (Fig. 10). It consists of a portal, by rails of which, with the aid of chain gearing, moves the trolley, carrying the working body of the machine - trowel head, place of operator, control panel, and the drive of rotation of the trowel head and trolley movement [5].

The portal of machine is a structure consisting of two longitudinal and transverse beams, drive of movement of the portal, frame of drive, flooring and fencing. On the longitudinal there are two-ledge wheels to move portal along the rails.

Cross beams carry the track to move the trolley. The drive of movement of the portal includes the electric motor, V-belt and chain transmission, and reduces. On the trolley of the machine, there is trowel head. In the lower part of the vertical shaft of head, floating discs are fixed. The drive of rotation of the disk consists of an electric motor and V-belt drive. Lifting and lowering of the disk, and control of it in the operation

process is made by hand via a lever system. To fix the drive in the upper inoperative position, a bracket-retainer is provided.

After completion of all technological operations form-trolley arrives on the platform of descender, and, together with the latter is lowered to the lower level; at the same time, the platform lift is lowered. When moving the platform down, the doors of the cells, kinematically connected through rope-block system with structure of elevator-descender and platform, are automatically opened at both butt-ends of the camera and form-trolley is delivered into the slit-type camera. After entering the camera of another form with the products, and return of descender and elevator to the upper position, the doors of the chamber sealed hermetically at the expense of movement of the platform upwards. The door is pressed against the butt-ends of the chamber by means of hooks and wedges installed on the door and interacting with the rollers mounted on the butt-end of the chamber. Concrete mixtures are delivered into the production department by belt conveyors.

Structurally, the chamber is designed in precast-monolithic design. The bottom and the walls of the chamber are made of reinforced concrete M-200, the floor is made of precast reinforced concrete slabs. On the plates, insulator is put, and the floor is arranged. This design allows to, after completing the bottom and walls of the chamber, to install rail track, registers and other equipment of the heating system and automation of the chamber. In various zones of the chamber, depending on the design typical loads, the registers are stacked on the floor, are hung on the side walls, and in the area of lifting, they are placed near ceiling surface.

The registers located near the ceiling surface are mounted by means of supporting beams, which, through the fingers are connected with metal tables with eyelets. This design of mounting (without bolts and welding) allows simply and fast to carry out installation, and if necessary, in the process of operation, to perform of dismantling of registers. The registers are connected between each other by threaded connections (welding is also possible).

In the area of vibratory plate, the area of the overlap of the chamber is made monolithic. With the purpose of convenience during repair work on parts of the camera, where there is no stationary technological equipment, in the ceiling of the chamber, openings are formed, lockable by lids and providing additional lighting, fresh air during repairs, and access to various parts of the chamber.

The heat treatment mode, and the parameters of the heating system contribute to provision not only the required strength, but also the humidity of products. The heat-carrier in the heating system is saturated steam. It is

supplied to the registers with pressure of 0.25 MPa. The consumption of heat energy per chamber is 3,48 GJ/h.

For mortars that are installed in different zones of the chamber, there are provided autonomous supply steam lines, that have electrified actuator system for automatic regulation of process of heat treatment, and manual gates, providing the launch adjustment in the period of maintenance works. The condensate is discharged from registers through condensate tapper to combined condensate line and condensate pumping station, from where by the pumps it is pumped to the heat source. Control of the pumps is performed automatically through sensors of level of condensate in the tanks. To ensure the forced heating chamber and coming into it forms with products, into the area of lifting and isotherm, direct steam is given through perforated pipes.

Control system for the entire process consists of a system of line control (set of mechanisms providing performing in the technological sequence of all necessary operations), control and management system for mode of heat treatment (control and maintenance of given temperature and humidity parameters in the zones of the chamber).

The power supply of the line is performed from the factory networks. Power equipment is provided with voltage of 380 V, the control circuit 220 V, in the alarm, 24 V. Control of line mechanisms is performed from the control panels. In the control panel, a switch is installed, allowing operation in remote or local mode.

For a given mode, the process control of thermal treatment of products in the chamber is carried out automatically. Basic electric circuit has two modes in chamber operation: automatic and local (selected by special switch). The temperature in the chamber is controlled and regulated by thermotransducers (sensors). The flow of heat carrier into the chamber is regulated by electrical serving mechanisms. Monitoring over the position of the adjustable valves is carried out by signal lamps. In the event of termination of heat supply to the system, an alarm turns on.

Because the quality of products and reliability of operation the entire plant, as well as the time of its putting on the design mode of operation to the maximum extent depend on the quality of the making of forms, the technological line includes control-assembly stand. It provides accurate assembly of the basic units of form, provides all forms of control over compliance of conjuncting dimensions with technological documentation.

In production of outer wall panels, a two-branch conveyor line, developed by Design Bureau of RSFSR Gosstroy and VNIIZhelezobeton

(Fig. 11) is characterized by high level of automation of technological processes The first line of this type is installed in Odessa [4].

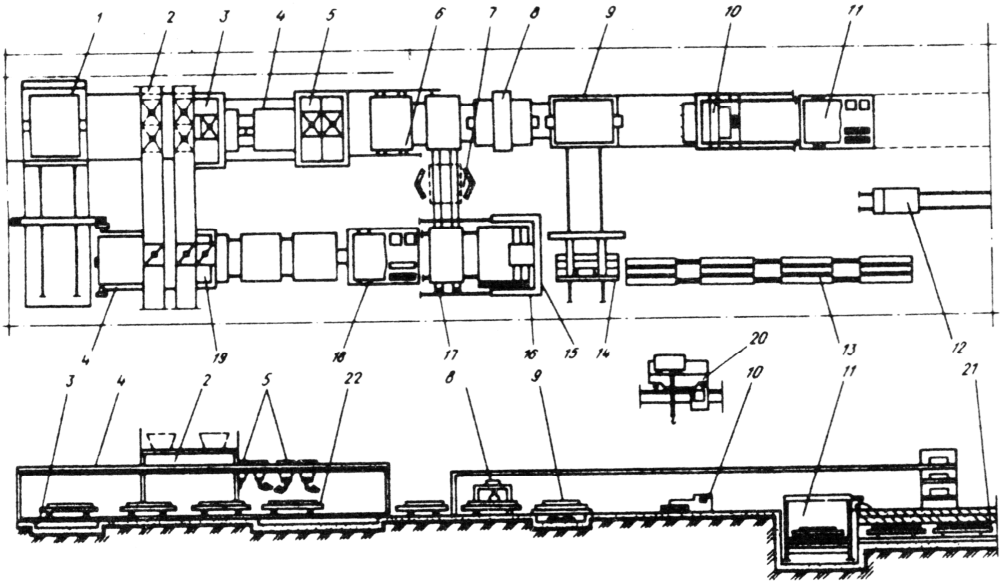

Fig. 11. Two-branch line for making outer wall panels (developer and VNIIzhelezobeton – All-Russian Scientific Research Institute for Reinforced Concrete): 1 – transfer car; 2 – construction trestle; 3 – suspended concrete paver; 4 – viaduct of concrete paver; 5 – suspended concrete paver; 6 – automated machine for open-closing of sides; 7 – hydraulic jack of moulds-trolleys; 8 – machine for cleaning and lubricating of moulds; 9 – turn-over device of moulds-trolleys; 10 – rubbing machine; 11 – elevator-descender (bringer-down); 12 – self-propelling export car; 13 – conveyor for finishing and stand-up of panels; 14 – self-propelled remover of panels; 15 – portal manipulator; 16 – elevator depository of changeable equipment; 17 – transfer bogie; 18 – descender (bringer-down)-elevator; 19 – mortar paver with smoothing body; 20 – overhead type electric crane; 21 – slit-type camera of thermal treatment; 22 – vibratory plate.

Conveyor line consists of two forming branches and two-branch underground slit-type chamber for heat treatment, going outside the production building (under finished product storage).
Forming branches are interconnected by a transfer car, adjacent to the forming department. Slit-type chamber is connected with forming branches through elevator and descender.

Supply of reinforcing elements to the posts of forming is made by an overhead conveyor, and installing of them in forms by manipulators. Warehousing of operational inventory of insulation (foamed polystyrene),

tiles, relief matrices and other materials is provided on the mezzanine of 2nd floor, and their delivery to the technical posts, in containers with a special device, through the opening of the 2nd floor.

As the main forming equipment, on the line there were installed concrete pavers and finishing devices, traveling on the overpass.
Finishing and aging of panels is performed on an overhead conveyor with retractable traverses, their return and exit to the warehouse of finished products.

The overhead crane is designed for handling installation and repair operations. In the production line all works associated with the movement of goods, are mechanized by local means on technological posts. To install this line, the preferred span is 24x144 meters. Two-branch forming line consists of 15 posts. On the line, it is provided the use of the new equipment: concrete paver with replaceable working bodies for the distribution of finishing, high-mobility and low-slump concrete mixtures; presser-out of opening-makers; a set of devices for their cleaning and stacking system; a manipulator for installation of millwork; universal machines for opening and closing the sides of the forms, their cleaning and lubrication; remover of panels with line and their installation on the finishing conveyor; set of devices for operational changeovers forms. The line capacity is 140 thousand m^2 of total living space per year.

Rational structure of technological streams, and complex mechanization of all operations made it possible to significantly increase the productivity, and to improve working conditions in comparison with domestic and foreign counterparts. Thus, specific labor costs can be reduced by about 1.5 times, and operating costs, and the prime cost of production, by 5-10%.

4.2. Technological lines for production of inner wall panels

Inner wall panels in precast large-panel construction amount by volume of about 40%. They have increased requirements on quality of surfaces. Inner wall panels are made by horizontal or vertical pattern. However, the most widespread scheme is implemented in cassette technology.

This is specified by high technical and economic indicators of cassette method of production of flat reinforced concrete products. Cassette installations are compact, reliable in operation, indicators of pick-up of products from 1 m^2 of production area with cassette technology is 10-15% higher than on horizontal conveyor lines. Specific metal consumption of

technological equipment with cassette production is smaller by 30%, and labour consumption is smaller by 14%. Products of cassette forming have well-defined edges, smooth surfaces and close to nominal geometrical dimensions, what is almost impossible to achieve with a horizontal forming. However, stationary cassette units have several disadvantages: low specialization and mechanization, difficult working conditions.

In subsequent developments, named as cassette-conveyor lines, separate operations of bench production are dismembered with further putting them on separate posts, allowing to perform the complex mechanization and automation of the main production areas. The calculated data show that the technical and economic indicators of cassette-conveyor technology is higher than cassette-bench production: the metal consumption can be reduced by 15-35%, the production area can be reduced by 10-15%, and labor costs, by 8-15%. In this process, it is possible to significantly improve hygienic conditions of the staff.

Cassette-conveyor line is a horizontal-closed conveyor of vertical forming. It performs the following processes: preparation and filing of concrete mixture, forming of panels, heat treatment of products and preparing of vertical forms. The elements of the cassette installation can move along both suspended and floor conveyor.

In Russian practice, there are several types of cassette-conveyor lines, developed by TSNIIEP of House Construction, EKB of Minuralsibstroy, Institute Giprostrommash, NIIZhB of USSR Gosstroy, NIISP of Gosstroy of Ukrainian SSR, SKTB Stroyindustria of Minsevzapstroy, and other organizations.

Cassette-conveyor lines differ in design features, including the method of moving the dividing walls; in technological characteristics: the method of delivery, placement, and compaction of the concrete mixture, method of heat treatment (one-stage, two-stage), the method of surface finishing etc. And still, the main feature should be considered the type and way of moving vertical forms or dividing panels.

All lines can be divided into the following types:

I - lines with a longitudinal shift of the vertical forms with products and specialized stationary forming posts for 1-2 forms, where forming is performed with following short (1-2 h) heat treatment, after which partial removal of formworks is made, and moving products into the chamber of the secondary heat treatment.

These are lines of SKTB Stroyindustriya of Minsevzapstroy of USSR (Kalinin (Tver), Novgorod, Kirov etc.), Orgtechstroy trust of

Glavvladivostokstrot (factory KPD-35 in Vladivostok), Gioprostrommash (Krivoy Rog), NIISP of Gosstroy of Ukrainian SSR (Kiev, DSK-1);
II - lines with transverse displacement of the forming boards, collapsible packet and the one-stage processing. Such lines are developed by EKB of Minyralsibstroy of USSR (factory in Kamensk-Uralsky, NIIZhB of USSR Gosstroy, TsNIIEP of House Construction - Parnassky and Gorkovsky (Nizhny Novgorod) factories;
III - lines with standard forming package for 16-18 forms, in which forming and heat treatment for 5-6 hours is performed, followed by complete removal of formwork from the products, and their transportation to the chamber of thermos soak to achieve the required strength.

Fragment of such line is designed by TsNIIEP of House Construction and first implemented on Tallinn DSK.

Each line type has its own peculiarities and requires individual consideration.

Central Scientific Research Institute of House Construction, Estonian Branch of SKTB «Stroyindustriya», and specialists of Kalinin (Tver) DSK have designed conveyor line with wedge shapes. It makes it possible to obtain products of full factory readiness. In addition, it reduces the impact of harmful factors on workers (vibration, noise, high temperature, evaporation of the lubricant), and increases labour productivity compared to conventional cassette technology, reduces specific energy consumption and metal consumption, it is possible to perform restringing of forms, production of a large range of products without decreasing the rhythm of the conveyor.

For the manufacturing of the inner wall panels on DSK, there was designed cassette-wedge conveyor for 5-, 9-, 16-storey houses of 111-121E series in the amount of 230 thousand m^2 of total living space per year. The pipeline is placed n the span 18x102 m with a mark of crane rail + 8,15 m.

The main element of the conveyor (Fig. 12) is an all-in-one package of wedge thermal shields assembled on rigid ties. Between the heat shields, there are formed wedge-shaped cavities, in which two-side forms are set. Delivery of forms to the package and their extraction is performed without disconnection of heat shields, with use of transfer car, so it is possible to avoid locking devices and other mechanisms. Before removing from the package, form with products previously shifted by the hydraulic presser-out. Removal of formworks from products, cleaning and lubrication of forms provided on one of three stationary post of removal of formwork and configuration. The fourth post is designed for simple repair and change-over of forms. The posts are equipped with hydraulic mechanisms of

removal of formwork, and platforms for maintenance of forms in two levels. To facilitate removal of formwork and elimination of breakage of products, lower rocker board is used on the forms. During the outhaul of the board the products are removed from equipment. Panels with removed formworks are installed by crane in the pit chambers of ripening, because on the line, two-stage heat treatment is applied.

On the first stage, products in the package of shields are being aged for 5 hours with two-sided heating shields and forms. On the second stage, due to the accumulated heat and the heat of hardening of cement, steam is not being delivered. So the chambers designed warmed with mechanized covers. This provides savings of thermal energy.

Duration of the first stage heat treatment allows to provide 50% stripping (removal of formwork) strength when working on conventional concrete mixtures without their preliminary heating, and chemical additions.

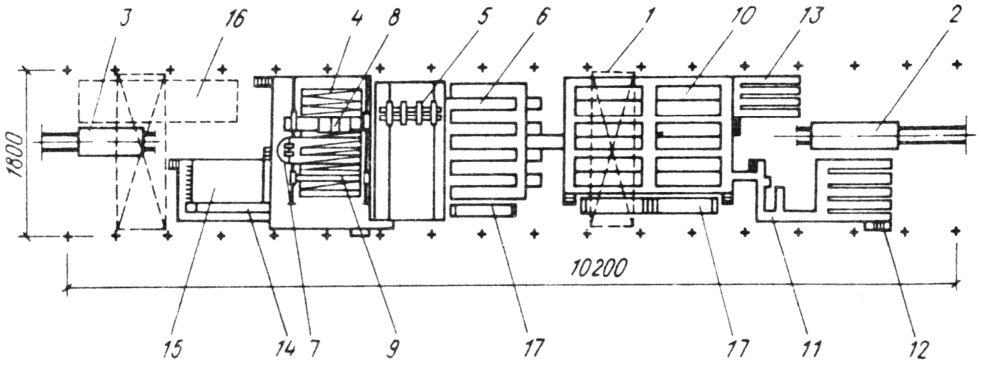

Fig. 12. Cassette-wedge conveyor:
1 – overhead-type crane; 2 – trolley for export of products; 3 – trolley for material supply; 4 - package of shields with wedge forms; 5 - transfer trolley; 6 - posts of removal of formworks and packaging; 7 - presser-out; 8 - concrete paver; 9 - compaction mechanism; 10 - chambers of ripening; 11 - shelves for finished products; 12 - posts of Technical Quality Control Department; 13 - posts of products repair; 14 - outdistanced roller conveyer; 15 - shelve for forms; 16 - site of repair and restringing of forms; 17 - container for reinforcement cages.

Removing the forms from the package of shields by longitudinal shift ensures the self-cleaning of shields. Good access to the form during lubrication virtually eliminates sticking of cement rock. Products are formed in the package of shields by concrete paver with seal of the mixture by comb of internal vibrators. Deep vibration provides receiving surfaces

of high factory readiness. Installation of wedge form to the package until it stops provides reliable abutment of board equipment to planes, reduces the leakage of the grout and allows to get the borders of panels of high quality.

This line does not solve issues of carrying all operations on specialized mechanized and automated posts, in particular, cleaning and lubrication of the heat shields. In addition, the manufacturing of equipment and its subsequent operation have increased requirements, otherwise, dense adjunction to the side shields will not be achieved.

Multi-section cassette-conveyor line, designed by NIIZHB of USSR Gosstroy, ECB of Minuralsibstroy, is implemented embedded in Kamensk-Uralsky factory of reinforced concrete ZhBI-3 of "Stroydetal-70" trust of Glavsreduralstroy. Cassette line differs from existing stationary cassette installations by decrease of power and metal consumption, reduction of number of staff due to the high mechanization and automation of production processes, increase of labour productivity. The line capacity is 40 thousand m^3 per year [6].

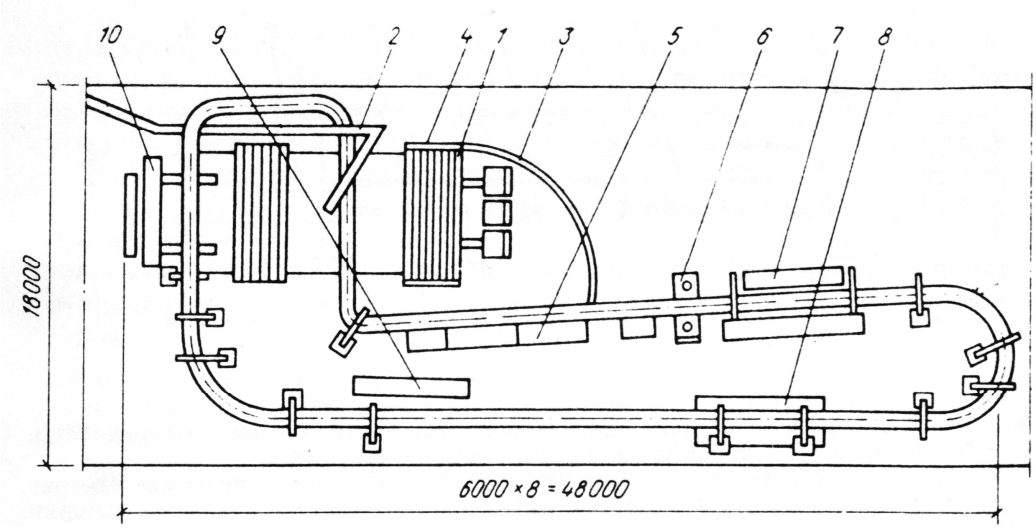

Fig. 13. Cassette line of EKB of Minuralsibstroy of USSR (Kamensk-Uralsky): 1 - cassette; 2 - concrete placing boom; 3 - cart for waste collection; 4 - rammer; 5 - stripping trolley; 6 - post of mechanized cleaning; 7 - post of manual cleaning; 8 - post of lubrication; 9 - post of installation of reinforcing cages; 10 - pushing trolley.

The line consists of the following main components (Fig. 13): the cassette from 50 forming compartments with additional accessories; pushing trolley; pick-up trolley; mechanized posts of cleaning, lubrication and installation of reinforcement into forming sections; overhead system of transport line [6].

The line has the following operating mode. mechanically Purified form, by monorail trolleys through overhead monorail transportation line is delivered to the post of automated lubrication, then to the post of reinforcement. Excess grease flow from the compartment into the pan under transported section (until the reinforcement post). Reinforcement from transport reinforcement trolley, with special crane-traverse, is removed, and is set by the operator into the form. For convenience of maintenance, the post is equipped with an elevating platform. Prepared form is delivered by the monorail to the pushing trolley (where pick-up of the form is performed from the hooks of monorail trolleys), with which it is installed on the trestle. Thus, on the trestle, by turns, collected the package of form-sections, prepared for forming. Heat sections alternate with dividing plates, on which vibrators are hung for compaction of concrete mixture. In the next time of installing the form, on the overpass the pushing trolley pushes the whole package of forms to one step. From the opposite end of the overpass, the removed form is picked up by the trolley, and the product is picked up by overhead crane. Hanging of form on the hooks of monorail trolley is automatic, slinging of the products, manually. By the turn of pick-up trolley, provides transfer of form-section to the transport suspended line, with which the form is delivered to the posts of preparing. The cycle of operations is repeated.

The line control is carried out in semi-automatic and manual modes with the remote control. Manual mode is provided from individual posts. The supply of steam is automated. Concrete pour is performed by using the concrete distributor from the concrete pump, mounted on the BSU under the concrete mixer. The performance of the concrete pump is 16-40 m^3/h.

Advantages of this method are significant: eliminates delamination of the concrete mixture, what improves the quality of the products (reduces the number and size of pores); save up to 15% of cement; reduced non-productive time losses for auxiliary operations during transportation of concrete mixture to the pouring site; eliminated losses of it; fully mechanized cleaning of concrete transportation vehicles.

On the pour of concrete mixture into cassette one worker is occupied. The line works in a daily mode. It is served by two workers in the first shift, one worker in the second shift, in the third shift, thermal treatment is made, controlled by automatic devices. The economic efficiency from the implementation is 200 thousand roubles per year.

Cassette-conveyor line, developed in SKTB of the USSR Minsevzapstroy, and operating on Kalinin (Tver) DSK is a horizontally closed floor conveyor of vertical forming, on which the following

technological processes are performed: supply of concrete mixture, forming of panels, thermal treatment of products in two stages, and preparation of vertical forms (Fig. 14).

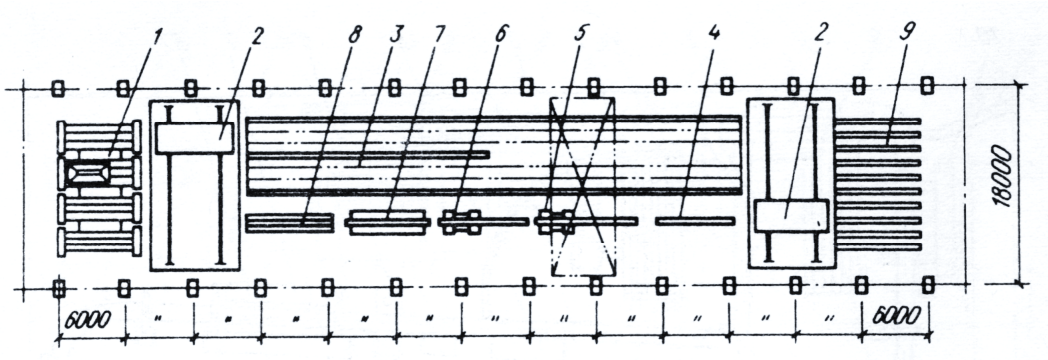

Fig. 14. Cassette-conveyor line for making flat products of precast large-panel construction, designed by SKTB Stroyindustriya of the USSR Minsevzapstroy: 1 - forming posts; 2 - transfer carriage; 3 - tunnel chamber; 4 - stripping post; 5 - post of cleaning forms; 6 - post of lubrication; 7 - post of installation of reinforcing cages; 8 - post of preheating forms; 9 - posts of change-over.

Technology provides the application of pre-warmed concrete mixture in the mixer SB-138 directly at the post of forming. When making mixture, hot water is used. Prepared vertical form using transfer car is delivered to one of the forming units. Hot concrete mixture with temperature of 40-50 °C is placed by the concrete paver into forming installation. Heat sections of installation and vertical form are heated by steam. Cleaning and lubrication of the forming installation is carried out by a special machine.

Formed products are aged directly in the forming installation at temperature of 80-85°C until the gaining of stripping strength. Then, vertical form with two products is transported by transfer car to a vertical tunnel chamber for the secondary heat treatment, from where, after 8.5 hours it is delivered to the first post of conveyor of preparation for removal of formworks with overhead crane, finished products are controlled on acoustic booth, then passed on to transport and finishing line and sent to the warehouse of finished products.

Vertical form after formwork removal passes successively the posts of cleaning and lubrication (with the help of special machines), change-over and reinforcement, preheating, then, by the first transfer car they are installed into the forming installation. Then the process is repeated. Control of cassette-conveyor line work is carried out with a separate remote and semi-remote control posts. The production department provides the places

for installation of ready for forming reserve vertical forms. On the same places, on the open areas without interrupting of production, with good access to the forms. re-adjustment, inspection and preventive maintenance are performed.

The main non-standard equipment of lines: forming installations, concrete pavers, transfer cars, drive machine for cleaning and lubrication of forming installations, conveyor for preparing mobile vertical forms, machine for cleaning and lubrication of vertical forms, vertical forms. The completeness of the equipment depends on the performance of lines that are currently used for manufacturing panels of the inner walls of large panel houses of series 111-90 and 111-121.

The experience of line operation made it clear that due to certain technological complications one could not manage to provide project time of thermal treatment of products in the installation itself, and this sharply reduces the output of cassette-conveyor line.

Considerable advantages has cassette-conveyor line of "Packet" type, designed in NIIZhB of USSR Gosstroy jointly with EKB of the USSR Minuralsibstroy (Fig. 15).

The line designed for use of several stationary packets with 15-20 sections in each, placed inside the loop of preparation container. Forming sections in the packet are oriented along the longitudinal axis of the production department. In each packet, preparing of single-type products takes place (by height, thickness, concrete type). Depending on the required output, the number of forming packets and sections in the line may be changed.

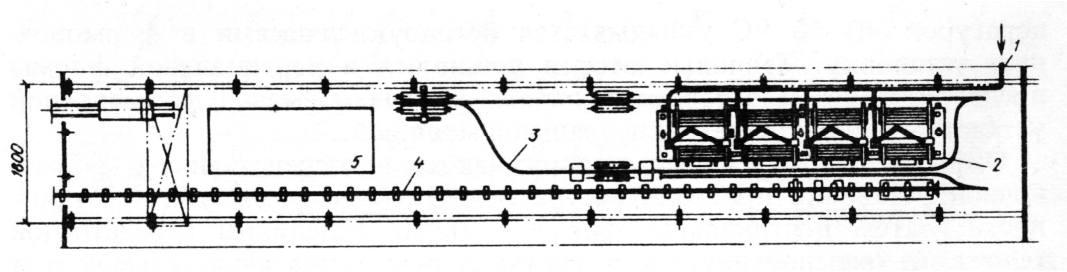

Fig. 15. Cassette-conveyor line of "Packet" type:
1 - concrete-pumping delivery of concrete mixture; 2 - cassette installations; 3 - conveyor for preparing cassette sections; 4 - conveyor of finishing of products; 5 - intermediate storage.

Transfer of forming sections may be performed through both rail tracks installed on viaduct, and on the level of the floor of production department.

Each packet is equipped with individual joining device, as well as with device for removal of formworks from products, and delivery of sections to preparation conveyor. The line provides finishing conveyor, as well as transportation line for delivery of ready-made products to it. Delivery of concrete mixture to the packets is performed with concrete pumps. Compaction may be performed with the aid of suspended or immersed vibrators, as well as individual devices, transferred under packet.

Due to conveyor mode of work, considerably increases the output of the line, and the output per one worker will be over 3 thousand m^3, and pick-up from 1 m^2 of production area will be 33,5 m^3.

In most technical-economical indices (Table 6), labour conditions and production organization, the production of plate products of precast large-panel construction on cassette-conveyor line of "Packet" type has advantage over other cassette-conveyor lines.

Table 6

Indices	Cassette-conveyor lines	
	«Packet»	City of Kamensk-Uralsky
Annual productivity, thousand per year	86,8	34,5
Maximum sizes of products, m	6,6x2,6x0,16	6,15x2,56x0,16
Output per 1 man per year, m^3/man	6200	5740
Labour costs, man-hours/m^3	0,34	0,65
Rhythm of operation of forming post, minutes	120	300
Amount of sections on forming posts, pieces	20x6	45
Specific metal consumption, kg/m^3	11,5	12,4
Pick-up from 1 m^2 of production area, m^3/m^2	33,5	-

In this process, specific metal consumption is under 30%, labour productivity, and pick-up from 1 m^2 of production area, respectively 55% and 40% higher. For improving the efficiency of cassette production, significantly influence is made by the modernization of reinforcement works.

NIIZHB, together with SKTB "Stroyindustriya" develops new principles and technical solutions for reinforcement production in

enterprises of precast large-panel construction and, first of all, for cassette production of slab products.

Larger part of reinforcement for the main product range is processed directly on the technological conveyor of production (PUMA installation for reinforcement of panels of outer and inner walls and ceilings), or on the second floor, as in the production of additional elements. Delivery of reinforcement steel to the production department from the warehouse is transported by floor transport, electric trolleys.

Reinforcing-welding production of reinforcement products consists of the following technological operations:

- preparing (straightening, cutting, bending);
- welding of plane frames and grids;
- punching, shot-blasting and metallizing of embedded fittings.

Straightening and cutting of coil steel on steel rods of specific cut length is carried out on straightening-cutting machines PSN-14 and SMZh-357. Cutting of reinforcement bars performed on the machine of S370, and bending of reinforcement, on the machine C146A. Guillotine shears K-19-002 allow cutting of sheet and profile metal.

Light and medium frames may be manufactured on automatic lines LSK-360U, mechanized lines PDS-8M (developed by SKTB "Stroyindustriya") and single-point welding machine of MT-1818 type. For welding wide meshes, there used automatic production line on the basis of stationary welding machine of ATMS 14x75 type, modernized by SKTB "stroyindustriya".

Transportation of the finished reinforcement products to the forming spans is performed with movable chain conveyors.

The new, and the most technological principle of reinforcement of the main types of structures, the method of winding directly from the coils with use of appropriate manipulator PUMA directly in the production conveyor, which requires fundamental changes in reinforcement of panels of outer and inner walls and ceilings. The design of the reinforcing frame of the panel is formed by winding of reinforcement on the tabs of the form (matrix).The creation of machines of PUMA type can solve problems of winding wire spirals on matrix-trolleys of cassette-conveyor lines for making slab products.

Due to the refusal of welding works, the bearing capacity of the reinforcing bars is used most fully, which results in reduced metal consumption.

4.3. Rotor-conveyor technological lines for production of reinforcement concrete products

To improve the efficiency of precast concrete production, radical reconstruction and technical re-equipment of the industry is required. In this process, it is necessary to apply new technological layouts of production, advanced technology and equipment, the use of manipulators, robots and computer technology.

The results of the work of Japanese studies, devoted to the analysis of the state and trends in the use of robots and manipulators in the construction and precast concrete industry, show that the main reasons hindering the implementation of robotics in the construction industry are:

- extremely wide range of products;
- significant dimensions and wide range of construction details;
- great diversity, complexity and wide range of manufacturing operations;
- weak feedback between the manufacturers and developers;
- inability to improve or change the process of manufacturing and structures due to significant regulatory restrictions.

However, industrial robots and manipulators combined with microprocessor technology are currently one of the most promising and versatile means of complex mechanization and automation of various technological processes.

Analysis of technological schemes of production, made by NIIZhB jointly with the VNIIZhelezobeton and Dnepropetrovsk branch of DF NIISP with the aim of raising the level of automation of the manufacturing of concrete and reinforced concrete products, allows to mention the prospects of a circular-rotor conveyors [4].

The technological process for rotor-conveyor lines is continuous: there is no idle running, stops between the intermediate operations; the rotor operates synchronously. In these lines, great potential is laid. And, above all, is the ability to automate the production of small products.

Advanced companies of France and England have developed manufacturing of concrete and reinforced concrete products on multi-purpose automated rotor-conveyor lines according to the method "Borcoman". In particular, the company "Maguin" (France) produces on these lines the following products: columns, piles, sleepers, walls, lintels, steps, gutters, curbs, slabs, beams etc. The main advantages of rotor-conveyor line, according to the experts of "Maguin" companies are:

- small capital investments with a wide range of products;
- reduction of operating costs through automation of production;
- quick interchangeability of forms;

- improving the quality of products;
- ability to move equipment from one construction project to another (mobility).

Productivity is very high and averages:

- columns, from 50 to 100 units per hour
- crossbars, from 60 to 120 units per hour
- gutters, from 100 to 200 meters per hour
- slabs, from 60 m^2 per hour
- cross-beams, 30 units per hour

Of the Russian designs, the similar type of rotor-conveyor lines may be considered the lines created by DF NIISP of Ukrainian SSR Gosstroy jointly with NIIZhB of USSR for production of blocks for basement walls and foundation plates (Fig. 16).

Rotor conveyor is a metal ring turning drain pan, placed on rail track, with installed on it preengineering wedge equipment, combined with heat treating chamber. Lever drives of sweep drive of drain pan, with certain time interval (cycle of conveyor work), move drain pan with moulds through all technological posts of forming and increasing of strength of products.

During the exit of another product from the ring chamber of heat processing, the mechanism of stripping of formwork, with the aid of hydrocylinder, shifts radially wedge element of attachments, releasing the product from them. After cleaning and lubricating of mould elements, the mechanism of assembly of formwork, with the aid of hydrocylinder, places the wedge element into the starting position for further forming. Compacting of concrete mixture is performed by the pack of deep-seated vibrators, which put into and taken out from concrete mixture with the aid of hydrocylinders. This makes it possible to reduce noise level and power consumption.

Ring turning drain pan with placed on it wedge formwork, passes through the ring chamber of heat processing, in this process three fourths of the pan is placed in the chamber, and the open part of the pan passes through the main technological posts.

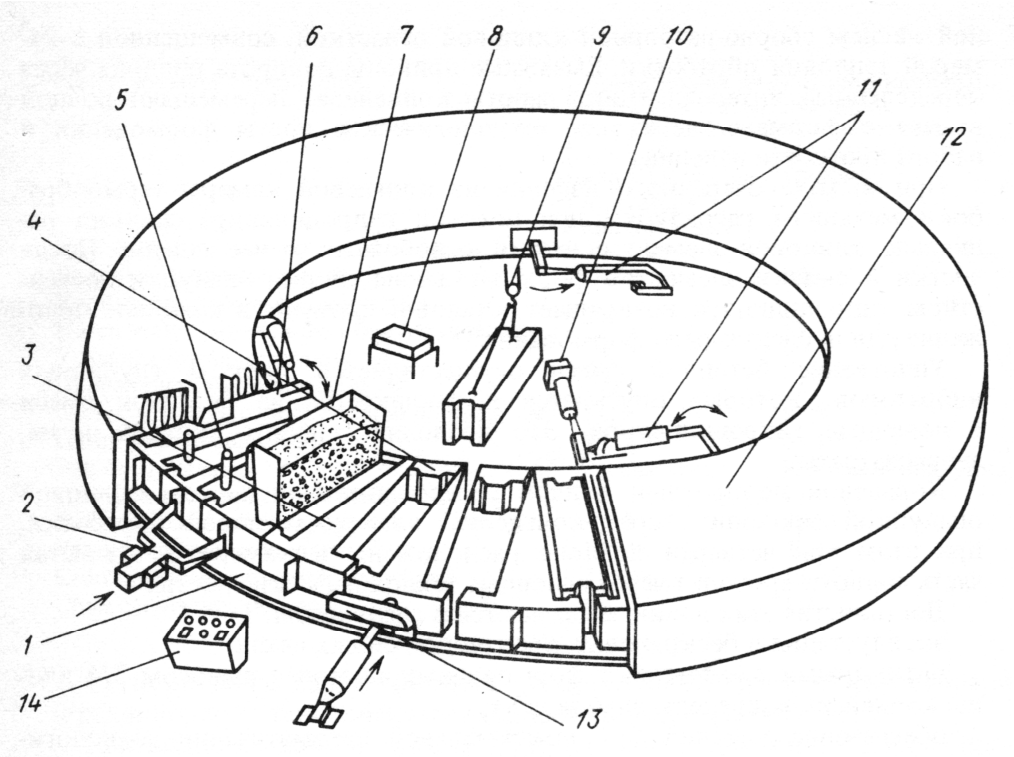

Fig. 16. Rotor-conveyor line for production of blocks of cellar walls: 1 - ring turning drain pan; 2 - fixation mechanism; 3 - wedge formwork; 4 - box-formwork of butt-end; 5 - vibropackage; 6 - mechanism for installation of hinges; 7 - accumulative bunker; 8 - hydrostation; 9 - mechanism of pick-up of blocks; 10 - mechanism of stripping of formwork; 11 - lever drive of sweep drive of drain pan; 12 - ring chamber of heat processing; 13 - mechanism for assembly of formwork; 14 - control panel.

Advantages of those lines are the following:

- operation in production departments without cranes;
- optimal configuration of forming posts with offset of 3/4 length of conveyor outside the building of production department;
- provision of conditions for maximum automating of technological processes (removal of transfer cars and traction mechanisms on butt ends of conveyors, and reaching optimally-coordinated rhythm of performing technological operations on all the length of conveyor;
- use of power-saving technologies of heat treatment of concrete;
- possibility of quick assembling of technological equipment and construction structures.

At the present time, rotor-conveyor lines on production of blocks of cellar walls are implemented in Kakhovka on the factory of reinforced concrete products (ZhBI USSR PO Ukrzhelezobeton), in Cherkassy,

Production association Cherkasszhelezobeton, in Zhitomir, Production association Selstroyindustriya, and in other places.

Analysis of technical and economical indices of the most progressive conveyor lines for production of blocks of cellar walls and foundation plates, given in the Table 7, allows to note high competitiveness of rotor-conveyor technological lines and reasonability of their wide-scale implementation for production of blocks of cellar walls, general volume of production of which is 4,2 million m^3.

Project Institute № 2 of USSR Gosstroy, following the technical project, prepared with NIIZhB (Institute for Reinforced Concrete), and DF NIISP, designed experimental working draft of production department with automatic rotor-conveyor technological line for making road plates with output 25 thousand m^3 per year.

Table 7

Name of indices	Conveyor line of Lutsk factory of reinforced concrete products (ZhBI-2, designed by KF KTB Stroyindustria)	Rotor-conveyor line (designed by DF NIISP, NIIZhB)
1	2	3
Annual productivity, thousand m^3	20	20
Number of workers per shift	3	2
Weight of technological equipment, tons	72	65
Specific metal consumption, kg/m^3	3,6	3,25
Production area, m^2	1397	216
Pick-up from 1 m^2 of production area, m^3	14,3	92,6
Forming cycle, minutes	15	5-10
Type of board equipment	Stripping of formwok	Wedge formwork
Period of thermal processing, hours	16	12
Annual consumption of electric power, Gkal	4243	2700
Installed capacity, kWh	113,9	20
Estimated cost of the line, thousand roubles	345,5	117,59
Pay-back period	4,4	1,3

Comparative characteristics of rotor-conveyor and conveyor (traditional) production lines are given in the Table 9.

As it is seen from the Table 8, change of traditional layout of conveyor production with rotor makes it possible:

- to increase output per 1 worker 1,8 times;
- reduce specific metal consumption or equipment 4 times;
- increase pick-up from 1 m^2 of production area 4,5 times;
- reduce specific consumption of electric power 5,3 times.

Table 8

Indices	Rotor-conveyor line (new equipment)	Konveyor line of Giprostroymash (similar)
1	2	3
Annual output, thousand m^3	24	24
Amount of workers per shift	5	9
Output by 1 worker per shift, m^3	9,7	5,4
Weight of technological equipment, tons	127	512
Specific metal consumption, kg/m^3	5,3	21,3
Production area, m^2	432	1944
Pick-up from 1 m^2 of production area, m^3	55,6	12,3
Specific consumption of industrial steam, $tons/m^3$	0,2	0,168
Specific consumption of electric power, kW, t/m^3	1,531	8,092
Annual economic efficiency (in comparison with the similar type), thousand roubles	100	-

NIIZhB of USSR Gosstroy performed analysis of technical-economical indices of production of reinforced concrete products with rotor technology. The results of the analysis are given in the Table 9.

Table 9

Ministry, place of implication, type of product	Designer	Maker	Productivity, m^3 per year	Amount of staff	Output per 1 worker, m^3 per year	Specific		Remarks
						metal consumption, kg/m^3	energy consumption, kWh/m^3	
Ministry of Construction of Belarusian Soviet Socialist Republic								
Minsk department of industrial house-building KPD №1, Minsk (sanitary engineering cabins with built-in ventilation units)	Design bureau of Minsk Assembly of Industrial house-building	Machine-building plants of ministries and departments of Minsk	8,6 * / 17,24	60 / 87	144 / 196	39,9 / 52,6	32 / 39	With account of finishing and packaging
Minsk assembly of industrial house-building, factory KPD № 3, Minsk	The same	The same	10,62	47	226	58,6	42	The same
DSK, Grodno, (sanitary engineering cabins, elevator shafts)	KTB Stroyindustriya of the Ministry of Southern Construction of USSR	PO Stroymash of Ministry of Construction of Belarusian Soviet Socialist Republic	7,21	19	380	58,6	45	-
DSK, Mogilev	The same	The same	5,76	25	231	79,5	55	Introduced in 1985
Ministry of Urals and Siberian Construction, USSR								
DSK, Sverdlovsk (ventilation units)	GPKTI Industroyproject of Ministry of Construc-tion Materials of USSR	Uralmash Plant, Sverdlovsk	16	14	1143	11,4	-	-

Ministry of North-Western Construction of USSR								
OP DSK, Kalinin (sanitary engineering cabins, elevator shafts)	SKTB Stroymekhanizatsiya (Construction mechanization) of the Ministry of North-Western Construction of USSR	Moscow plant of the assembly "Stroytekhnika" (Construction equipment) of the Ministry of North-Western Constructionof USSR	12,5	12	1042	20,6	6,4	-
Ministry of Eastern Construction of USSR								
Plant of Reinforced Concrete products ZhBI № 2, Khabarovsk (sanitary engineering cabins)	Trust Orgtechstroy of Glavdalstroy (Construction organization of the Russian Far East)	Remstroymash plant, Khabarovsk	8,16	7	1165	25,9	32	Project
Gosagroprom (State agrarian industry) of Belarusian Soviet Socialist Republic								
Assembly «Belselstroy», Molodechno (sanitary engineering cabins)	KTB Stroyindustriya (Construction Industry) of the Ministry ofthe Southern Construction of USSR	Pinsk casting-mechanical plant of the assembly "Belselstroy" (Belarusian Agrarian Construction)	5,2	24	153	91,5	-	With account of finishing and packaging

Ministry of water economy of USSR								
Plant of reinforced concrete products (ZhBI) "50 years of USSR", Kakhovka (blocks of cellar walls)	Dnepropetrovsk branch of NII SP Gosstroy of the Ukrainian Soviet Socialist Republic	Kakhovka OEMZ of the Ministry of Water Economy of USSR	20* 12,9	4 3	5000 4300	3,3 3,3	1,2 2,3	-
Ministry of Municipal Economy of Lithuanian Soviet Socialist Republic								
Experimental plant of construction structures, Kretinga (paving tiles)	NIL FKhMMiTP of Glavmospromstroymaterialy	Experimental-mechanical plant of Glavmosproms troymaterialy	7,0	2	3500	4,3	6,9	-

*Over the line is project data, under the line is actual data

CONSLUSION

In the general volume of precast concrete, about 80% are flat and linear elements, what makes it possible to perform specialization and concentration of production for creating of automatic lines. In design of such lines problems arise, connected with certain technological operations.

Preparing of concrete mixture is one of the most important technological operations, which may be completely automated. At the present time, it is necessary to perform modernization of concrete-mixing units with use of new (including high-speed mixers), dosing devices with strain-gauge sensors, units of preparing and activation of additions. Mixing equipment, whenever possible, must provide activation of all components of concrete mixture.

In carrying out reinforcement works, welding equipment is being widely used. During the process, reduction of labour intensiveness may be achieved due the following measures:

- unification of reinforcement products with reduction of amount of dimension-sizes of precast concrete products (reduction of dimension-sizes of precast concrete products 2-3 times will reduce the amount of dimension-sizes of reinforcement products 10-15 times);
- automation of reinforcement works in making all types of welded bar mat reinforcements and frameworks, as well as embedded fittings;
- automation of works on production of prestressed structures with use of wire-winding machines, especially with use of steel wires of small diameter 7-6 mm, as well as helical reinforcement.

In last decades, for compaction of concrete mixtures, there were created technological bases and developed low-frequency equipment in frequency range 10-25Hz, and in the technology of precast concrete two tendencies took shape:

- first (the most widespread) is linked with use of moving and cast mixtures, and use of plasticizers. For forming of products according to this technology, any type of low-frequency equipment may be recommended, and, first of all, with symmetrical oscillations;
- second tendency considers use of harsh mixes with the purpose of reduction of stock of moulds. For such technology, in the basic version of vibration equipment, two-frequency operating mode is used (low

frequencies during compaction of moving mixtures; low and average during compaction of harsh mixes);

- rather successful for making road structures from fine grain concrete are controlled modes with vibropressing.

One of the most efficient methods for intensifying of solidification of concrete is electric thermal treatment for areas with continental severe winters. In areas further south than 50° northern latitude, in reconstruction of enterprises of precast concrete, it is supposed to widely use technological principles of production with use of heliotechnology and combined technology with double power source of electric power.

Modernization of enterprises of precast concrete is necessary to perform on the basis of creating lines providing output at least 550 m^3 of precast concrete per man per year. First of all, it is highly-mechanized and automated production lines of conveyor type: rotor-conveyor, cassette-conveyor, and semi-conveyor. In modernization of enterprises of precast concrete, it is reasonable to provide development of rotor-conveyor technology, which makes it possible to remove a number of drawbacks, inherent from traditional types of conveyor production, and create conditions for complete automation of technological processes.

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TABLE OF CONTENTS

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