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USSR Report

RESOURCES

(FOUO 6/80)

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ELECTRIC POWER AND POWER EQUIPMENT

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TECHNICAL PROGRESS IN THERMAL EQUIPMENT INSTALLATION

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 11, Nov 79 pp 6-7

[Article by V. A. Kozhevnikov, deputy minister for Power Engineering and Electrification of the USSR: "Basic Directions of Technical Progress in the Area of Thermal Equipment Installation Projects"]

> [Text] From the Editorial Board. The Energomontazhproyekt Institute, created 10 years ago, is working productively toward perfecting the organization and technology used in generating projects for the installation of equipment at TES's and AES's. Below are published articles in which the Institute's most effective developments are illuminated.

In the 3 years of the 10th Five-Year Plan, equipment with a combined output of 23.8 million kW has been installed and put into service at TES's and AES's that are under construction. This includes four power units of one million kW capacity each at the Kursk and Chernobyl'skaya AES's, six 800 MW power units at the Zaporozh'ye and Uglegorskaya GRES's, as well as a number of power units of lesser capacity. A substantial increase in the technical-economic indicators for installation projects has been attained.

By the end of the Five-Year Plan, 22.7 million kW of new capacity must be put into service. This includes power units that have been delivered: the main 1,200 MW power unit at the Kostroma GRES; 1,000 MW power units at the Chernobyl'skaya, Smolensk and Novovoronezhskaya AES's; one 800 MW power unit at the Ryazan' GRES; and six 500 MW units at the Reftinskaya GRES and the Ekibastuz GRES-1.

The rate at which new output capacities are commissioned will increase rapidly in the 11th and 12th Five-Year Plans. At the same time, the following qualitative changes are planned in thermal electric power development:

an increase in individual unit output;

an increase in the AES's contribution to the over-all structure of commissioned capacity, especially in the European portion of the USSR;

an increase in the contribution of coal-fired TES's (especially those operating on low-caloric and high-ash coals) in the structure of commissioning all thermal electric power stations;

--accelerated development of power production in the country's northern and eastern regions;

--an increase in requirements for environmental protection.

All of this stipulates increasing the volume and complexity of installation projects in terms of the commissioned capacity.

For example, if the mass of thermomechanical equipment needed to produce 1 MW of output at an 800 MW gas/fuel oil fired power unit comprises 37 tons, then a 500 MW power unit using Ekibastuz coal has 62 tons for each MW, an 800 MW unit on Berezovskiy coal has 63 tons and an AEC power unit with an RBMK reactor has 50 tons.

At the present time, the labor expenditure for the installation of one ton of equipment amounts to 9-10 man-days at a TES and 15-18 man-days at an AES.

Possibilities for further increasing the number of installation workers are limited. Therefore, a required condition for the execution of this planned program of thermal electric power development is a reduction in labor expenditures on equipment installation brought about by improvement in the technology and organization of installation projects, and increase in the level of their mechanization and also by perfecting design solutions.

The installation of equipment is the crowning step in rigging an electric power project. The time it takes to put a project into service depends upon the duration of the installation work; besides this, the major portion of capital investments is usually already obtained by the time the equipment is installed. Thus, the duration of the installation, together with the labor and material consumption in the installation work, determines the effectiveness of the capital investments. The efficiency of the operation is directly connected to its quality of execution, since the elimination of any installation defect demands an additional expenditure of time as well as labor and material resources.

The work on increasing the efficiency and quality of the installation must not be directed toward carrying out isolated measures. It is necessary for the work to be conducted smoothly and objectively while the latest scientific-technical achievements and advanced experience are employed.

Toward this end, in 1969 a decision was adopted to organize the Energomontazhproyekt Technological Design Institute. In the ensuing 10 years, the Institute carried out a number of projects directed at increasing the efficiency and quality of equipment installation at TES's and AES's.

In the area of thermal equipment installation projects, the chief tasks connected with increasing the efficiency and quality of installation work are:

perfecting TES and AES designs;

increasing the degree to which equipment is factory-prepared;

developing and introducing new installation methods;

industrializing installation projects, transferring as much of the volume of such projects as possible to the plants, bases and assembly areas;

improving the technology of welding operations, including heat treatment and quality control of the welds;

increasing the level to which the operations are mechanized, developing and introducing new, very productive installation mechanisms.

The designs for TES's and AES's must fully insure the feasibility of adopting efficient installation technology. In order to do this, the development of the design at all stages (especially at the early stages) must be conducted with the participation of the installation technicians, that is, with the participation of the Energomontazhproyekt Institute.

The joint work of the Institute and the plants--manufacturers of the basic equipment--must be accomplished in a corresponding manner. At the same time, it is expedient to incorporate in the equipment's design solutions which ensure that the equipment can be dismantled into its delivery units with a minimum of scatter, and which ensure the feasibility of guiding a large-scale assembly directly into its planned location using apparatus that does not require the piece to be set down along the way. The design of the units should ensure that the stresses imposed during installation are absorbed through the units' internal rigidity.

The number of welding operations in the area of installation must be kept to a minimum. In order to do this it is necessary to provide for the option of carrying out the major portion of these operations during assembly of the units on the construction platform.

Owing to the efficient design of the equipment, the rigid tolerances of its manufacture and also because of the necessary testing and checking of the assembly that is conducted at the plant, it is essential that labor-consumptive fitting operations be eliminated in the installation area.

The Energomontazhproyekt Institute must take an active part in the development of standards and technical specifications for the delivery of equipment, while striving to include in these documents requirements for improving installation technology. The Institute must also participate in approving the technical specifications for the delivery of equipment at concrete projects.

The perfecting of the design for the boilers' dust and gas flues (PGV's) and for non-standardized equipment at TES's and AES's is of great significance in reducing the expenditure of metal and labor in manufacturing and installation. The basic directions for work in this area should be the standardization of group decisions and the standardization of components and elements; the adoption of refined accounting procedures which would eliminate the unfounded increase in the mass of the dust and gas flues; and the adoption of efficient designs for components and elements (fireboxes of circular cross-section, flexible, non-metallic expansion joints, etc.).

In the area of installation technology the main attention must be directed toward increasing the modular nature of the equipment. The design of an installation module of optimal dimensions and mass should ensure its connection with all the assemblies and components of the thermomechanical section, the thermal insulation and also elements of the measuring instruments and the power unit.

The complex and multistage technological processes, including the installation of oil lines for the turbine plants and KhVO [further expansion not provided] pipelines, adjustment of the permanent linings, etc., must be replaced one step at a time.

It is necessary to perfect methods of centering and aligning the turbine equipment, the internal hull arrangement of the reactors, etc., and to broaden the area of application of optical and laser instruments in order to carry out these operations.

The unification of designs; the standardization of assemblies and components of the pipelines, dust and gas flues and technological metal structures; and the modernization of the factories of Glavteploenergomontazh create the prerequisites for the further industrialization of installation operations and the change-over from the centralized manufacture of semi-finished installation materials to the centralized outfitting and assembly of equipment modules.

This trend is particularly effective in the continuous construction of large scale fuel and power production complexes. It is essential to insure the introduction of industrial production technology at the Ekibastuz Regional

Industrial Assembly Base (RPKB), the construction of which is being completed at the present time. We must also insure the issuing of working drawings for the RPKB [further expansion not provided] of the Berëzovskaya GRES, planned for operation in 1982, so that the technology put into the project can be applied even during construction of the first unit of the Berëzovskaya GRES-1.

The experience of assimilating the installation technology at the RPKB of the Ekibastuz GRES must be studied, and utilized during planning of RPKB's of prospective electric power complexes, as well as during planning of the interconnected bases of installation trusts in areas of concentrated power equipment construction.

A most important task is the further development of the technology for welding, heat treatment and the quality control of the welds. At present, 10-12 percent of the total labor expenditure for equipment installation goes toward carrying out these operations, and the quality of their execution is one of the basic factors determining the reliability of the equipment's operation.

The improvement of installation work technology is inseparably linked to the further development of mechanization. An increase in the units' individual power outputs and, correspondingly, an increase in the height of the main housings and the weight of the units require the construction of cranes which have a lifting capacity and lifting height that considerably exceed those adopted previously. These cranes must have an increased speed of lift and must ensure the feasibility of their rapid assembly and disassembly. Cranes of folding or sectional design and of low lifting capacity are needed for operation in the closed, isolated chambers of AES's.

Despite the installation workers' desire to reduce the amount of adjustment work, the demand for equipment to carry out these operations is growing. The technical requirements for these devices in the areas of productivity, accuracy and ease of installation and service are also increasing. The time needed to produce the new devices, which at the present time is excessively long, should be reduced owing to the creation of the Institute's production base and the singling out of a factory in the Teploenergooborudovaniye trust for the manufacture of rigging equipment.

Along with the development of devices and apparatus for technological purposes, we must also perfect accessory equipment intended to ensure safe working conditions (scaffolding, cages, stock enclosures, etc.).

In many ways, the efficiency of the installation operations depends upon the high-quality delivery of auxiliary and non-standard equipment, low-pressure pipelines and other items, manufactured by the Glavteploenergomontazh plants.

In order to satisfy the growing demand for these products on the part of builders in the power industry, it is necessary to sharply increase the output of these products by the construction of new plants, as well as by reconstruction and expansion of existing plants. At the same time, we must also carry out the qualitative development of this industry in order to guarantee a substantial increase in operating efficiency. In the designs for new and refurbished plants we must plan for the maximal mechanization and automation of production and the adoption of new highly productive technological processes. At the same time,we must develop designs for products on the basis of their standardization and consider the requirements for progrsssive technology in their manufacture.

Toward the solution of the problems just enumerated we must direct the labors of the Energomontazhproyekt Institute and those design and scientific research institutes of the USSR Minenergo that collaborate with it.

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ELECTRIC POWER AND POWER EQUIPMENT

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METHODS OF INCREASING EFFICIENCY OF TES, AES EQUIPMENT INSTALLATION

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 11, Nov 79 pp 7-11

[Article by Engineer Yu. S. Medvedev]

[Text] In order to speed up technical progress in the areas of organization and technology needed to carry out operations for the installation of TES and AES equipment, the Energomontazhproyekt Institute was created ten years ago and the following directions for its activity were determined:

perfecting the organization of manufacturing operations, installation technology and welding of thermomechanical equipment at TES's and AES's;

developing designs for high-efficiency lifting machines, installation devices and the means of small-scale mechanization;

designing factories to manufacture auxiliary boiler equipment and low-pressure pipelines, as well as production bases for the installation trusts;

designing dust and gas flues for boilers, developing standardized components for auxiliary boiler equipment and low-pressure pipelines.

Work in these directions, which at the present time remain predominant and determining, aids in the reduction of construction time and the lowering of construction costs for TES's and AES's, in the conservation of material resources and aids in the increase of operating efficiency on the part of installation workers and laborers at auxiliary boiler equipment and pipeline plants.

The Institute constantly seeks new methods to increase the efficiency of equipment installation at TES's and AES's. The institute's sections are participating in the work of the chief designer at the very earliest stage of TES and AES planning, including development of the general construction plan, the composition of equipment in the main building and the selection of lifting devices. Thanks to such cooperation, a basis is being created for the application of progressive installation technology and the complex mechanization of rigging and assembly operations.

The introduction of the Institute's proposals makes it possible to reduce the volume of work and the cost of construction, thanks to a more efficient distribution of primary and auxiliary equipment. For example, according to a proposal from the Institute's Khar'kov affiliate for the standardization of machine-room layouts, the positioing height of the crane rails and, correspondingly, the height of the machine rooms were reduced by one meter at the machine rooms of the Berezovskaya GRES-1 and the Perm and Chigirin GRES's. These stations have power units of 800 MW capacity. In addition, the layout of the boiler works' rear section was changed. This made it possible to introduce a standardized scheme for the mechanization of the equipment installation. The application of this proposal for each of the 18 boilers at the three GRES's will insure a reduction of the labor expenditure by 1,800 man-days and of the construction time by two months. The realization of a proposal from this very same affiliate for improving the layout of the TPP-312A boiler unit at the Zuyevka GRES-2 will allow us to save 250 tons of metal on the boiler and to reduce labor expenditures on the installation by 1,400 man-days.

The work of the chief designers and installation engineers during the designing of an AES acquires particularly great significance, since the installation of equipment in isolation cubicles is associated with great difficulties and requires great expenditures of labor. For example, the development by the Institute of an efficient distribution of primary equipment in the air-tight portion of the reactor room in the AES's special building (holding a commercial VVER-1000 reactor) makes it possible to conduct the installation of heavy equipment "right off the wheels" (they plan to install special elevating mechanisms in the isolation cubicles). It has become possible to reduce the labor expenditures by 79,000 man-days and the cost of construction by two million rubles.

The Institute is taking part in work on standardizing AES design decisions, in particular, on developing a design for a commercial atomic power station with VVER-1000 reactors, a design which will be used during construction of the Zaporozhskaya, Volgodonsk, Khmel'nitskaya and other AES's.

In the process of work on improving design solutions for AES's with VVER-1000 reactors, reactors for which the Gidroproyekt Institute is developing a standardized design, the construction and layout of the emergency localizing basin has been changed. This will make it possible to decrease the construction cost by 200,000 rubles.

The chief designers and affiliates of the Energomontazhproyekt Institute must expand the local work on designing power production projects, since while doing this they achieve not only a reduction in labor consumption and construction costs, but also a reduction in the construction time. In our opinion, it is necessary at this stage of atomic power plant design to entrust the technological institutes with the development of a corresponding division "Organizational Planning of Construction."

The high level of installation technology and the modular nature of the primary and auxiliary equipment when delivered has a decisive influence on raising the installation workers' efficiency. Thus, it is very important that the installation engineers assist the workers at the Design Bureau's machine construction plants in creating the design of the main units. Work at the institute is being conducted in this direction, but as of yet it is not extensive enough.

According to contracts with the Ordzhonikidze Plant and the Turbine and Boiler Plant, the basic arrangement have been worked out for increasing the level of installation technology for types P-64-1, P-70, P-67 and TMP-501 main boilers (1000, 1650, 2650 and 1800 tons per hour, respectively) and for the high-pressure VPG-600 steam generator. According to a contract with the Barnaul Boiler Plant, similar developments have been carried out on the BKZ-420-140 KS boiler with a fluidized bed and the RKZ-420-140 LPI boiler with vortical stoking.

Work on increasing the technological level of the TPE-214 SKhL boiler for the Neryungrinskaya GRES has been carried out in conjunction with the Turbine and Boiler Plant. This work has allowed us to bring the amount of modular installation work up to 90 percent and to decrease the labor expenditure by 1000 man-days. Designs for the reactor supports were developed by the Institute when agreement was reached on the technical design for the commercial variant of the VVER-1000 reactor's steam generating equipment. The standardized "dry shielding" design that had been proposed allows us to carry out all assembly, welding and quality-control operations under plant conditions.

Relating to the number of basic proposals for the RBMK-1000 reactor are: the elimination of installation mounts on the upper and lower plates of the biological shielding; the elimination of 16 installation man-holes on the upper plate of the additional, secondary shielding; and the delivery of the reactor shell, expansion joints, the annular tank for the secondary shielding and the shield cylinders in consolidated modules. The introduction of these proposals will permit us to reduce the labor expenditures by 10,000 man-days on one power unit alone. This testifies to the fact that the Institute's work with the design bureaus and the plants that manufacture AES equipment must be expanded. In particular, the Institute must take part in approving the technical requirements for the delivery of equipment.

The Institute's specialists are working in close contact with the design bureaus of the power equipment construction plants and are achieving realization of these proposals at the earliest stages.

The USSR Minenergo can render considerable scientific-technical advice at the same time. In the section of construction and installation operations the Scientific-Technical Council must examine equipment designs from the standpoint of increasing the degree to which they are ready for installation and must also solve the problem of setting a limit for the execution of projects with the Minenergomash. It is expedient that Minenergomash, together with the USSR Minenergo, develops new All-Union Standards for the delivery of equipment.

The systematic work of the Institute toward improving the design and standardization of auxiliary boiler equipment and low-pressure pipelines manufactured by plants of the Teploenergooborudivaniye trust, aids in reducing the metal expended on their manufacture and the labor expended on their installation.

In 1979 planning was carried out for standardized mounts and suspension supports for dust and gas flues and low-pressure pipelines. Drawings and All-Union Standards were developed for reservoirs at thermal electric power plants. We have begun developing drawing for standardized stainless steel reservoirs for AES's.

A new design for lenticular expansion elements for pipelines with a shortened lens allows us to significantly expand their application by raising the pressure from 0.6 to 1.6 megapascals. The creation of partially relieved lenticular expansion elements makes it possible to reduce thrust force on the mounts by a factor of Z.

A great economic impact is provided by work done by the Institute on perfecting and standardizing the grouping of auxiliary equipment and the boilers' dust and gas flues.

Proposals to improve the grouping and the design of the gaslines for the TGMP-1202 boiler at the 1200 MW power unit of the Kostroma GRES have guaranteed an 800 ton savings in metal expended.

The introduction of standardized groupings of the auxiliary boiler equipment of the type TGME-464, TGME-454, TPE-208, BKZ-420-140 PT-2 main boilers and the KVGM-100 water-heating boiler provides a savings of labor and metal expenditures. For example, the standardized grouping of the TPE-208 boilers (for the Shaturskaya, Cherepovetskaya, Smolensk and Pechora GRES's) and the TGM-96/B's (for the Severnaya, Riga, Kishinev, Nizhnekamsk and Saransk TET's) allows us to reduce metal consumption in the gas flues by 55 and 82 tons per boiler, respectively.

Thanks to the development of a single set of working drawings for 75 to 80 percent of the gas flues at the Penza, Saransk, Severodvinskaya and Orlov TETS's, the savings in metal for each boiler, on the average, amounts to 60 tons. These drawings will also be used during the construction of several other TETS's.

The adoption of seven standardized auxiliary boiler arrangements for 93 boilers at 43 electric power stations put into service during the current Five-Year Plan will permit us to save 4,300 tons of metal and reduce labor expenditures by 15,300 man-days.

Working drawings for dust and gas flues that were done for the TETS's ZIGM [further expansion not provided] have been adopted at eight electric power stations.

Instead of right-angle gas flues of large cross-section, round rolled flues are now universally employed, which make it possible to reduce the metal expended by 20 to 40 percent and the labor expenditure by 35.

Research work is being conducted on replacing the lenticular metal expansion elements with flexible expansion elements made from fireproof fabric. Calculations during planning of the auxiliary boiler equipment are carried out on a computer.

The greatest reserves for increasing the efficiency with which the installation operations are performed are revealed during development of POS's and PPR's [further expansion not provided].

During development of installation technology for the TGMP-1202 boiler of the Kostroma GRES's 1200 MW power unit, the following progressive solutions were accepted: the assembly and installation of bracing beams were done in stacks along the entire wall of the furnace or convection shaft; the placing of the maximum number of modules in their design locations without the use of temporary suspension devices; the construction of through-ways in the covers of the deaerating stacks in order to deliver equipment and conduits to all designated spots with the aid of a lifting crane. The introduction of these solutions will allow us to reduce the labor expenditure by 200,000 man-days and reduce the metal expended in the manufacture of installation devices by 600 tons.

Besides this, we have worked out the technical documentation for assembly of the K-1200-240, K-1030-65/1500, T-175/210-130 and K-500-130 turbines using an optical method. Technology has been developed for checking the axial and vertical alignment of the VVER-1000's reactor channels by the optical method, as well as technology for the construction of instruments and devices used to carry out these operations.

A significant economic impact is achieved during organizational planning of the thermal equipment installation operations at AES's. In only the last few years work expenditures have been reduced by 190,000 man-days and the cost of construction by 726,000 rubles as a result of improving organizational work at the Kursk, Chernobyl'skaya, Smolensk and Southern Ukraine AES's.

Thanks to the introduction of the more refined technology suggested by the Institute, the periods of installation of equipment in the reactor sections of the Chernobyl'skaya and Southern Ukraine AES's were reduced by 90 and 25 days, respectively; the labor expenditures at both AES's were decreased by more than 20,000 man-days; and the cost of construction was lowered by 70,000 rubles.

Particularly indicative are the results from the development of installation technology at the No. 2 power unit of the Chernobyl'skaya AES. Thanks to the introduction of new technology (a considerable portion of the operations done in the reactor shaft is transferred to a shop where further assembly is performed) the installation of equipment in the reactor section was carried out in seven months, as opposed to the twelve required when using the old technology, and the power unit was put into operation within the established period of time. Labor expenditures on the installation of equipment at the No. 2 power unit of the Chernobyl'skaya AES have been considerably reduced in comparison with similar indicators attained during construction at the No. 1 power unit. On the basis of the experience acquired, we expect to reduce labor expenditures on the installation of the No. 3 power unit of the Kursk AES by 104,000 man-days in comparison with the installation of the first unit.

Although the Institute pays sufficient attention to the development of equipment installation technology for the reactor and the reactor compartment, questions about the organization and execution of installation work on the auxiliary boiler equipment and pipelines, as well as about the execution of installation operations in the auxiliary shops, for the time being are encompassed only to an inadequate degree. This, in particular, can explain why labor expenditures for mounting the equipment at an AES equipped with the RBMK-1000 reactor are three times higher than at a TES and one and a half to two times higher when equipped with the VVER-440 and VVER-1000 reactors.

A series of authors' reviews and working designs, created by the Institute for large-scale power plant construction projects, renders operational assistance in solving questions that arise in the course of installation work.

Work is being done on standardizing the devices used in the assembly and installation of thermomechanical equipment, with the goal of organizing their manufacture at the plants, their repeated use and a decrease in the metal expended in their production.

Great attention is being paid to improving the technology of welding and heat treating. We have introduced the technology for automatic welding, done under a layer of flux with a metal cover, for consolidating the upper and lower slabs of the biological shielding of the RBMK-1000 reactor of the Smolensk AES. Technology has been developed for the mechanized plasma-arc welding of thin-gauge stainless steel structures, as well as a design for the plasmatron and a follow-up system along the depth of the weld. On the basis of investigations carried out by the Institute, a decision has been adopted to eliminate the heat-treating of weld joints on pipes made from 12Kh1MF steel with diameters of up to 219 mm and wall thicknesses of up to 18 mm. This provides a savings of about 100,000 rubles per year.

New brands of electrodes have been developed for welding austenitic steel. We have developed a heat-treat process for welds on tubing made from 12Kh1MF steel that allows us to reduce the duration of the process by a factor of 2 or 3 times. We have also devised a method of heat-treating weld joints in the stainless steel pipes in operation in BN-600 liquid-metal heat-transfer reactors. The introduction of this method makes it possible to obtain a practically non-oxidized inner pipe surface, decrease the expenditure of shielding gas and reduce the time needed to accomplish heat-treating.

The accelerated development of atomic power demands an improvement in engineering training, the organization of the operations, the installation technology and the AES welding equipment.

The standard time frames for submitting design-estimate documentation and providing metal and pipes to the Teplenergooborudivaniye trust's factories for the manufacture of pipelines and non-standard equipment (NSO) have become obsolete. Besides this, they were designed to be applied at TES's.

The Institute has determined the optimal time frames for the construction of VVER- and RBMK-equipped AES's and the delivery of equipment to them. This should contribute to the development of the optimal sequence for delivery of equipment, pipelines and non-standard equipment, as well as the sequence of execution for construction and installation operations. Because of this, it will be feasible to carry out a gradual sequence of equipment installation. This is particularly important during the installation of equipment within isolation chambers.

A great impact is had by the combination of construction and installation operations. This makes it possible to use the construction organization's hoisting mechanisms for the set-up of large-scale equipment.

It is expedient to develop a plan for standardized AES production bases and to determine a schedule of temporary structures, their dimensions and designs.

Since the number of installation workers reaches more than 2,000 men during the one to one and a half years needed to construct a large-scale AES and put it into service, it is necessary to create a clear-cut administrative structure for the thermal equipment installation workers.

It is necessary to direct great attention to the training of the personnel who will install the first units. The installation organizations are obligated to develop corresponding measures, utilizing experience derived from installing similar equipment at other electric power stations. The engineering and technical personnel should study in advance the design documentation and the guide-line and instructional materials.

Immediately after approving the technical design of an AES, it is necessary to develop a master network schedule, including times for submitting technical documentation, the construction section's readiness for installation, the delivery of equipment and materials, the meeting of requirements for hoisting and installation mechanisms, etc.

The most important tasks for the Institute and the installation organizations in the area of improving the technology of TES installation equipment in the period up to 1985 are:

1. The introduction of a high-speed continuous production method of installation with the execution of the pre-installation operations on the RPKB at the Ekibastuz GRES complex. The technology for pre-installation preparation of the RPKB's 500 MW power unit equipment with the P-57 boilers, as well as the technology for the continuous production of this equipment, was developed by the Institute's eastern affiliate in 1977-1978. They took into account the installation experience acquired from setting up similar equipment at the Troitskaya and Reftinskaya GRES's. However, due to a lag in RPKB construction, the pre-installation preparation and the installation of the equipment for the first power units are being conducted by traditional methods. The main task consists of introducing new methods of performing operations on the third and fourth power units and of making a complete changeover to industrial methods of performing the operations at the RPKB, as well as a changeover to a rhythmic installation.

By the beginning of the equipment installation at the GRES-2 it will be necessary to develop designs for transport methods, as well as the technology for delivering and conveying large-scale units to the installation zone by means of specialized motor transports. Since a significant portion of the equipment and rigging at the Ekibastuz RPKB was planned first, the construction and arrangement of this equipment will demand finishing.

2. The development and introduction of technology for continuous production operations upon installation of equipment at the Berëzovskaya GRES-1 and consequent GRES's of the Kansko-Achinskiy Thermal and Electric Power Complex with pre-installation preparation at an RPKB. At these GRES's, new-type (P-67) boilers will be mounted. These suspended, dense-gas boilers with a 2650 ton per hour steam-generating capacity, in connection with the properties of the fuel used, differ in dimensions and mass from the TGMP-204 boilers. For example, the mass of the P-67 boiler is more than twice that of the TGMP-204 boiler. Correspondingly, the volume and complexity of the operations increase.

3. The development and introduction of technology for the installation of equipment at GRES's with 500-800 MW power units (Pribalkhashskaya, Perm, Chigirin, Surgut-II and others). During work on these projects we will use installation experience derived from similar equipment at the Zaporozh'ye, Uglegorskaya and Ekibastuz GRES's. Most of the design solutions will be standardized, based upon the Perm and Chigirin GRES's, both of which were supplied with the same type of equipment, while others will be standardized after taking into account design solutions at the Berëzovskaya GRES.

It is necessary to note that the Institute is insufficiently occupied with questions of perfecting the organization and technology of the installation of equipment in the subsidiary shops and the organization of subsidiary operations (such as transportation, equipment servicing and the management of the tool shops), although the consumption of labor there is comparable to that in the primary operations.

In order for the Institute to devote greater attention to the development of production planning operations for large-scale projects, it is necessary to free it completely from the development of production planning operations on actuating and water-heating boiler projects and on boilers of the DKVR [further expansion not provided], having obiliged the installation workers to follow the frequently employed plans that had been developed by the Institute for similar projects.

It is impossible to solve the problem of increasing efficiency without the development of high-output methods for mechanizing the installation and welding operations. The Institute has done little in this direction. Plans have been created for more than 100 mechanisms and devices. However, only 20 have been put into commercial production, which can be explained basically by the absence of an experimental production base for the Institute and of manufacturing plants for commercial equipment, and by a deficient supply of component items. Working drawings have been produced for a bank of machines used in the complex mechanization of the process in which pipelines are installed within the turbine condensors; for standardized, automatic welding machines, type ATM, for austenitic steel pipes of 57-108 mm diameters and automatic machines, type APC, for welding the bellows into the circuit of the RBMK-1000 reactor channel; for the ASTN-1000 and ASTV-1 automatic machines which weld non-rotating joints on pipes with a 850 mm diameter main cross-section, made of plated steel; for a machine tool to work the ends of 159-273 mm diameter stainless steel pipes, etc.

Considerable work is being done on designing lifting cranes for the installation of equipment. Unqiue cranes have been built: a 640-ton capacity gantry crane for the installation of metal structures for AES's, a 2 x 100 ton capacity overhead crane with a 110-meter lift for the installation of suspended boilers, etc. They have standardized gantry and semi-gantry cranes, set up within the main TES building, and they are planning for the replacement of the 70 type sizes for cranes with 4 type sizes in 8 configurations. Plans have been developed for freight slings which make it possible for overhead cranes to lift equipment possessing masses considerably (up to 50 percent) exceeding the lifting capacity of the cranes. This makes it possible to reduce the mass of the metal structures in the main TES building.

As a consequence of specializing the designs of AES equipment, a considerable portion of the installation mechanisms, devices and mechanized tools used at TES's can not be employed at atomic power plants. Thus, the Institute has specially developed equipment for welding and installation operations at AES's. They have put into production machines for adjusting the metal structures of the RBMK-1000 reactor; for dressing weld seams on the channels and for cutting the edges of the facing plates; mechanisms for finishing weld seams and for the removal of defective seam sections; mechanisms for welding the channels to the networks and the metal structures; and installation for austentizing cold bends in the pipes, etc. The economic impact from the introduction of these mechanisms comprises about 300,000 rubles.

In order to reduce the time needed for designing, manufacturing and putting into production examples of new installation and welding equipment, it is necessary to create at the Institute an experimental production base and improve the supply of its component items, as well as to set aside a specialized plant at Glavteploenergomontazh for the production of these installation devices only and to solve the problem of manufacturing control equipment.

The further expansion and deepening of projects by the Energomontazhproyekt Institute in the directions mentioned will contribute to a significant increase in the efficiency of TES and AES equipment installation.

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ELECTRIC POWER AND POWER EQUIPMENT

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IMPROVING THE METHODS OF AES EQUIPMENT INSTALLATION

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 11, Nov 79 pp 11-13

[Article by Engineers A. M. Gusinskiy and M. Ya. Khizhin]

[Text] The rapid development of nuclear power engineering is a most important condition for raising the technical and economic level of the country's entire power production economy.

At the present time, the consumption of labor and time required to put power units into service at AES's are inferior to similar indicators achieved during construction of TES's. For example, the unit labor expenditure on equipment installation at AES's using RBMK-1000 reactors comprises, on the average, 0.8 to 0.9 man-days per 1 kW of designed power, and the duration of the AES's power unit installation with assembly of the RBMK-1000 reactor's metal components is equal to 2 to 2.5 years, while the installation of an 800 MW power unit at a TES is carried out in the course of 9 to 10 months.

The most important task governing the improvement of AES construction in the near future is reducing by a factor of two the unit labor expenditures for thermal equipment installation operations in comparison with labor expenditures for the installation of the No. 2 power unit at the Chernobyl'skaya AES, where they comprised 6 man-hrs/kW.

In order to achieve this goal, the following basic methods have been projected:

1. A reduction in metal consumption for equipment, metal components and pipes. The Energomontazhproyekt Institute, along with electric power station chief designers, is conducting work on improving equipment layout decisions and designs for separate assemblies. The introduction of the Institute's proposal for changing the design of the steam distribution pipeline assembly of the RBMK-1000 reactor's system for breakdown containment made it possible to reduce metal consumption in the assembly (by 114 tons per power unit) and labor consumption during installation. A new solution for lining the pipe runs at the Smolensk, Chernobyl'skaya and Kursk AES's made it possible to considerably reduce metal consumption in the pipes and to decrease the amount of work on adjusting and cutting pipes and then facing them.

2. Providing for the delivery of large-size component modules from the plants. During development of the working documentation, specialists from the Institute disassemble the equipment into delivery and installation modules. This is done in order to insure component module delivery of equipment within the limits of railroad dimensions and takes into account the fact that the equipment will be installed by industrial methods. Such work was conducted, in part, during planning of the metal components for the service platforms and the pipelines.

3. Improving the methods of installation for primary and auxiliary equipment. Equipment developers, as a rule, when designing equipment and studying the basic solutions to questions of maintenance and repair, do not devote enough attention to the methods of installation. Experience shows that the participation of installation technicians in the design of equipment provides positive results. The development of the boilers and pipelines for thermal electric power stations and the design of equipment for AES's can serve as examples of this. For example, altering the sling assembly of the biological shielding's upper tank according to the Energomontazhproyekt Institute's proposal made it possible to raise considerably the level of installation modularity in the RBMK-1000 reactor's metal components and to carry out test fitting. Because of this, installation time was reduced by more than two months. Proposals were also developed for improving the installation methods for all of the reactor's equipment. All of this testifies to the necessity of legitimizing the participation of a specialized institute in the development of electric power station and equipment designs.

4. The organization of efficient schemes to deliver equipment to the installation zone and the organization of mechanized methods of operation. This task must be solved jointly with the Atomenergostroyproyekt Institute, since construction operations and the installation of equipment at AES's are conducted concurrently. One must devote attention to the sequence in which the operations are carried out, taking into account the organization of the ordered installation and mounting of large-scale equipment in the design locations, and using the builders' lifting machinery while the construction operations are being conducted.

5. Carrying out installation and welding operations with high-efficiency equipment. During construction of the Chernobyl'skaya AES the Institute developed and introduced devices for assembly of the reactor's metal components, for dressing seams on the welded channels and for removing defective metal, etc., from them. The reduction in labor expenditures due to the introduction of these mechanisms amounts to tens of thousands of man-days. However, there are still many other processes amenable to mechanization. It is also necessary to solve the problem of a production base for the manufacture of experimental models of this equipment and their limited production.

Specifications for the installation of equipment at atomic electric power stations are dependent upon the increased demands for cleanliness and quality in carrying out the operations. The presence of isolation chambers in closed areas in which equipment, including large-scale equipment, is arranged creates additional difficulties during the organization and execution of operations at AES's.

In order to increase the efficiency of installation operations the Institute has developed:

flow charts for the installation of the basic equipment and pipelines in the forced recirculation, live steam and feed-water circuits;

equipment delivery routes and hoist layouts;

schemes for the location of throughways and their dimensions, as well as schemes for the location of mounting components for the installation of equipment in isolation chamber and in closed areas;

a scheme for organizing the unloading of heavy equipment for pre-installation preparation and its subsequent delivery to the installation zone.

Energomontazhproyekt, in conjunction with the Gidroproyekt Institute, used common standard pipeline components and utilized sharply bent and curved elbows, made with the help of high-frequency currents, during development of the working drawings for pipelines at the Kursk, Smolensk and Chernobyl'skaya AES's. This made it possible to reduce considerably the amount of welding and quality-control work. A reduction in component nomenclature made it possible to insure the industrialization of their manufacture.

The development of a plan for the installation of large-scale modular equipment in the RBMK-1000 unit's emergency containment system merits attention.

The system's equipment contains a great many modules for the steam distribution pipes (BPT's). The method of installing the steam distribution pipes in the slabs with subsequent concreting through a hole in the casing did not allow for conducting the installation in the modular method. Changing the mounting assembly of the steam distribution pipe on the suggestion of the Institute made it possible to accomplish the assembly of the pipes and the covering plates in consolidated modules on the assembly platform. Concreting of the inter-plate gap is accomplished when it is tilted through 180 degress in the consolidation process. A special tilting mechanism was specially developed to turn the module over.

The introduction of a new method for installing the emergency containment system equipment at the Chernobyl'skaya AES made it possible to reduce the number of hoisting operations from 680 to 150, save 114 tons of metal, eliminate manual labor in the delivery of 450 cubic meters of concrete and decrease considerably the amount of work in welding end caps.

In order to organize the large-scale modular installation of equipment in the emergency containment shaft of the No. 1 power unit at the Rovenskaya AES, the Energomontazhproyekt Institute changed the design of the tower's diffuser assembly. In the preventative maintenance schedule that was developed, the Institute provided for the following installation method for this equipment: assembly of the mounted and supported tanks, cover plates, bottom plates, dome sections, service platforms and other components in modular form up to 27 tons is done on special stands; these modules are then delivered to the shaft; and they are completely assembled on an installation truss in sections of up to 70 tons mass, hoisted and installed in sections in their operational position. The introduction of this method insures a 4000 man-day reduction in the labor expenditure.

The organization of AES equipment installation operations requires one to conduct engineering training, including the participation of the Energomontazhproyekt Institute in the development of the following schedule: the delivery of technical documentation by the chief designer; a concurrent execution of construction and installation operations that takes into account the utilization of construction cranes for the installation of thermomechanical equipment in isolation chambers and closed compartments; the manufacture and delivery of equipment and pipeline; and a master schedule for the installation of thermomechanical equipment that is linked to the time of delivery of such equipment and material support.

The work of the institute with the manufacturing plants makes it possible to improve the feasibility of installation and the modular delivery of the equipment. At the present time, the equipment that arrives at the project site often makes it necessary for the installation organizations to do the finishing work in place. It is necessary to make it legal to draw the Institute into participation in the development of new AES equipment at the technical design stage, and also into the approval of the technical specifications for its delivery, as was done with the TES's.

During the last few years, the Energomontazhproyekt Institute has made a great contribution to the development of installation methods at AES's equipped with RBMK-1000 reactors.

At the Kursk AES they carried out the assembly and installation of the reactor's metal components with the help of a three-flight scaffold mounted at the end of the reactor compartment. The scaffold had built-in temporary work enclosures and two 320-ton capacity cranes mounted on it. Such a layout had shortcomings right along with its merits--it was necessary to disassemble and again set up the scaffold with the temporary work enclosures and the cranes at the next unit. In connection with this, the Institute proposed carrying out the installation of the reactor's metal components in a three-section shop for consolidated assembly (the temporary work encloses), erected in zone of the No. 2 power unit outside of the main building. For the assembly, manipulation, transportation and installation of the metal structure the Institute developed the special KP-640 gantry crane with a 640 ton lifting capacity. The chief virtue of the new arrangement is the fact that the assembly of the reactor's metal components is not dependent upon the state of readiness of the reactor compartment's construction section. Besides this, it has become possible, owing to the presence of a crane, to unload heavyweight equipment and mount the separators and the collectors. The introduction of this scheme during the installation of the two units in the I line of the Chernobyl'skaya AES had an economic impact to the sum of more than 800,000 rubles.

Particular attention was devoted to improvement of methods of assembly, welding and installation of the equipment for the reactor compartment. In the flow charts prepared by the Institute, they provided for the execution of the maximum number of operations in the combined-assembly and pre-installation work shop, and also on the assembly and consolidation platforms through the use of automated welding and the application of a sufficient number of devices. This made it possible to consolidate the reactor's metal components into six installation modules and to conduct a test assembly before their installation at the No. 2 power unit of the Chernobyl'skaya AES. As a result, the reactor's metal components were mounted in 15 days (whereas three months were spent in carrying out this work using the old method). Besides this, the accomplishment of final consolidation and test fitting in the temporary work shelters made it possible to erect the reactor's metal components before the installation of the graphite masonry in 57 days (instead of 128 with the old method).

For the No. 2 power unit at the Chernobyl'skaya AES, the Institute has also developed a method for installing the graphite masonry that provides for the maximal mechanization of the work. All operations are done with the help of special equipment and devices. As a result labor expenditures for the installation of the masonry have been reduced by 1,150 man-days and the duration of the work by 10 days.

At the same power unit they introduced a more refined method for the installation of steam communications and for group installation of the technological channels. Pipelines for the steam communications were collected and installed in half rows. Technological channels were installed in twos and fours with the application of a special cross piece, which made it possible to reduce the time needed to carry out the operations along the critical route.

Due to the introduction of progressive methods, a considerable reduction in the duration of the installation work, an increase in its quality and a reduction in labor consumption has been guaranteed. For example, the unit labor expenditures during installation of the second power units at the Kursk and Chernobyl'skaya AES's were 27 percent lower than similar indicator's attained during construction of the first units.

For the Novovoronezhskaya AES's power unit with the VVER-1000 reactor, the Institute developed progressive design solutions for the organization of the operations and a method for installing the units primary equipment. These were directed at reducing labor expenditures and the time needed to perform the operations. For example, in order to avoid delays when carrying out operations in the reactor shaft, they provided for the assembly of the reactor's upper unit in the inspection shaft with preliminary consolidation of the assemblies on the assembly platform. This was done in the flow chart for the installation of the upper unit. In the flow chart for the installation of the PGV-1000 steam generators they provided a scheme for the installation which allowed them to essentially reduce the installation gaps. Because of this, the time needed to carry out the construction and installation work is significantly reduced.

The Institute has also created highly efficient means for small-scale mechanization of assembly and installation operations: machines for adjustment of the reactor's metal components, for dressing weld seams and for cutting the facing plates; a device for removing defective welds; an assembly for austenizing pipe bends, etc.

The majority of progressive design solutions developed by the Institute for AES's have been carried out on a new level of engineering. The economic impact from the introduction of only these operations comes to more than a million rubles per year.

At the present time work is continuing on improving the organization of installation operations and the methods of installing AES equipment.

When drawing up flow charts for the installation of auxiliary reactor equipment, pipelines, metal components, machine hall equipment and the deaerator stages, particular attention is devoted to the development of flow charts for the combined installation of equipment and pipelines in isolation chambers and sealed compartments. These charts are to contain the formulation of the assembly records and the establishment of an installation sequence. This will make it possible to group the equipment, pipelines and metal components for each isolation chamber and install them together. Such an organization of operations eliminate the necessity of returning to mount the equipment in the same isolation chamber.

For the second lines at the Kursk and Chernobyl'skaya AES's, measures have been drawn up which are directed at insuring that the units are put into service within the times established by the directives. These measures provide for the careful development of engineering preparation in production; for the development of both operational organization and methods of assembly, installation, welding and quality control of equipment; for the improvement of design and structural solutions; and for the creation and introduction of new machinery. The introduction of these measures will allow us to reduce labor expenditures on the installation of mounted power units by 25 percent in comparison with the labor expenditures on the first power units.

This accumulated experience and the standardization of design solutions for one type of power station create the prerequisites for the creation of technical documentation for a repeat application (particularly the flow charts).

During development of the technical documentation for equipment at commercial AES's with reactors of 1000 MW, 1500 MW and greater capacities, it is necessary, when taking into account the growing requirements for quality installation, that one uses the experience accumulated and seeks out new methods for improving the organization of the installation operations and the methods of installing the equipment and the pipelines.

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ELECTRIC POWER AND POWER EQUIPMENT

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ORGANIZATION OF ELECTRIC-POWER SUPPLIES FOR GES

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 11, Nov 79 pp 41-43

[Article by Engineer I. E. Veyts: "Efficient Organization of Electric-Power Supplies to GES Construction Platforms"]

[Text] During the erection of large-scale hydraulic developments, many modern construction methods and means of mechanization are used, including such power-consumptive construction mechanisms as powerful excavators, dredges, etc. A considerable portion of the electric energy is consumed by construction bases alongside the project, by the builders' settlements and during the development of the excavations.

The maximum power load during the construction of large-scale hydraulic developments sometimes amounts to 20-30,000 kW. At the same time, the electric power consumption of the construction base in the period of its full development reaches 25-28 percent of the total electric load, and in the case of utilizing the dredges for erecting the main structures, the loads can increase by a factor of 1.5 to 2.

During construction of the Volzhskaya GES's imeni V. I. Lenin and imeni CPSU 22nd Congress, the electric load of only the dredges comprised 38,000 and 20,000 kW, respectively. The estimated electric power of the hydraulic mechanization facilities for the type of alluvium in the Boguchanskaya GES's earthen dam would come to 50,000 kW.

During the construction of isolated projects in areas having severe climatic conditions, electric heating for the production and the housing areas, as well as electric heating for carrying out particular types of work, are brought about by special authorization. In this case, the loads from the electric heating alone can reach tens of thousands of kilowatts. For example, the maximum power consumption at the construction sites of the Ust'-Ilimskaya and Boguchanskaya GES's, where electric heating is used, reaches 250,000 kW.

In determining the electric loads, we isolate those responsible consumers for whom a disruption in the electric power supply is not permitted (water drainage and boiler systems and illumination of the foundation pits) and consumers that are seasonal in nature (hydraulic mechanization facilities, electric heating).

Particular attention is devoted by designers and builders to the preparatory period, at which time the pioneer production base is built and the primary electric lines are run in. At this time, construction loads are comparatively light.

It should be noted that the necessary attention is not always devoted to questions of the electric supply in the preparatory period. In these cases, the running in of the electric lines, particularly during construction of projects removed from the power system, lags behind the pace of construction operations. This leads to an increase in the normal period of construction. For example, the first link of a 220 kV high-tension power line-- a 250 km section to supply electric power to the construction site of the Boguchanskaya GES--has been under construction for four years. At the Zagorsk hydro-accumulation elelctric power station, located in the center of the Mosenergo system, the erection of short approach lines from the 110 kV high-tension electric power line to the construction site's primary step-down substation (GPP) required three years.

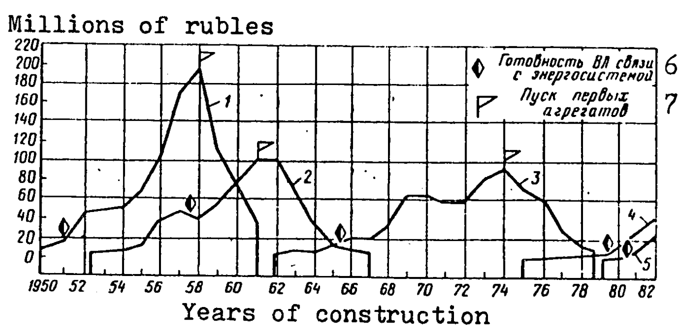

Fig. 1

Utilization of the means of carrying out construction and installation work as dependent upon the supply of electric power to various projects. 1-Volzhskaya GES imeni 22nd CPSU Congress; 2-Bratsk GES; 3-Ust'Ilimskaya GES; 4-Zagorskaya GAES; 5- Kayshyadorskaya GAES; 6-Readiness of high-tension line connections with electric system; 7- Commissioning of the first power units.

In addition to this, even more time went into installation of the primary step-down substation, as a result of which the transition period from the preparatory to the basic stages was prolonged. The extent of the facilities used in executing the construction and installation operations depends, to a significant degree, upon the feasibility of supplying electric power to the construction site (fig. 1).

Upon selecting an electric power supply scheme for a project, one must take into account the sequential nature of the construction's development.

In the preparatory period, as a rule, on-site sources of electric power (diesel or gas-turbine electric power plants of various outputs) are utilized: 400 kW/400V type-DGU automated diesel-electric power plant units; type ASDA power units of 1000, 1600 and 2000 kW and 6.3 and 10.5 kV capacities; type ESDA portable diesel electric power plants of 200 and 500 kW/400V capacities; type GTE 1600 and 2500 kW/6.3 kV electric power plants on rail cars.

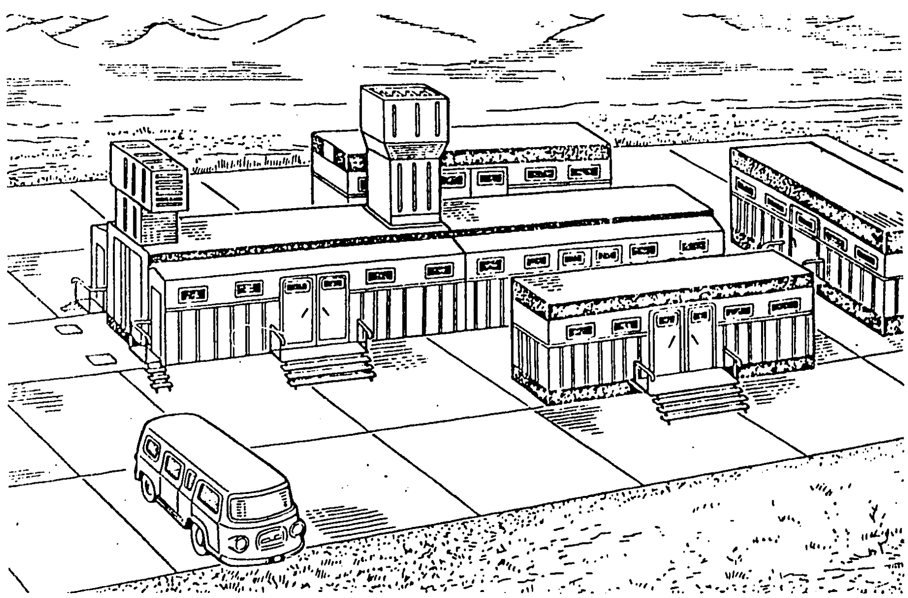

Fig. 2 12,000 kW capacity gas-turbine electric power station [BGTE]

At the second stage, when the electric transmission lines connecting the construction platform to the electric power system are put into service, the on-site electric power sources are used essentially as emergency sources, and sometimes even as a load reserve. Only when there is a reliable link-up of the construction platform to the electric power system along two or more high-tension lines does the requirement for on-site electric power sources fall off.

In isolated cases, when the hydraulic development's line of direction is considerably removed from the electric power system, the on-site power plants are used throughout the entire period of construction (as, for example, during the construction of the Khantay GES). However, such sources of electric power are not always economical and reliable.

At the present time, industry has mastered the production of the BGTE modular transportable gas-turbine electric power plant of 12,000 and 24,000 kW and 6.3 or 10.5 kV outputs (fig. 2). Such electric power plants operate steadily for prolonged periods of time, in all modes, in temperatures of -50 to 50 degrees centigrade.

It is expedient to bring about the supply of electric power to construction platforms from the regional power system along permanent electric transmission lines, the construction of which must be completed by the time operations are begun on the primary structures. Along these same lines, the delivery of output power to the electric power system will be accomplished after the station's first units are put into operation. In addition, the primary step-down substation and other elements of the construction site's distribution network must be built allowing for their future use as permanent providers of electric power to the regional consumers.

For example, the electric power supply to the Boguchanskaya GES construction site on the Angara is accomplished along two 220 kV high-tension lines from the Irkutsk electric power system through the Sedanovo-Boguchanskaya GES switching point (fig. 3).

Within the settlement's communal zone is located the 220/110/10 kV primary step-down substation with 3x125,000 kV·A autotransformers. From the substation, the settlement's boiler house is supplied at 10 kV, while all construction site, airport service, sovkhoz and timber management consumers are supplied at 110 kV. For the electric supply to the settlement it was necessary to install two 16,000 kV·A/110/10 kV transformers at the primary step-down substation in connection with the fact that, according to accident prevention requirements, the joint operation of the electric boilers and other electric power consumers is not to be tolerated.

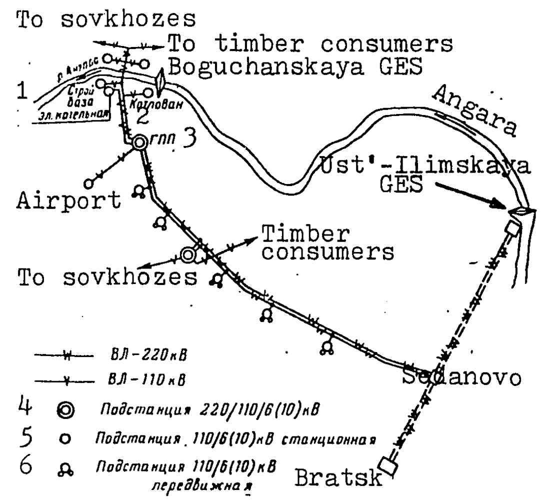

Fig. 3 Layout of electric power supply to the Boguchanskaya GES construction site.

1. Construction base and boiler plant
2. Excavation pit
3. Primary step-down substation
4. Substation
5. Fixed substation
6. Mobile substation

There are two double-circuit 110 kV high-tention lines that run under the power station building to the construction base and the foundation pit. To these lines, four KTPB's [further expansion not provided] of 2x16,000 kV·A/110/6 kV capacity and one 2x80,000 kV·A/110/10 kV capacity substation for the electric boiler construction base are connected.

A 2.5 km double-circuit high-tension line crossing the Angara, with supports set in the riverbed, is planned for the delivery of electric power to the right bank.

The 220 kV high-tension lines that are built will be used subsequently to deliver the output of the Bogichanskaya GES's first units to the region of the Bratsk electric power development and to supply the regional 220/110/6 kV substation.

The 220 kV high-tension power line is being constructed in stages. Along the first line a 110 kV voltage will be conveyed temporarily. To this line (along the route) they will connect five portable transformer substations on vehicle trailers, type PKTPA-2500/110, designed at Gidroproyekt. From these substations, they will bring about the supply of electric power for construction of a road to the Boguchanskaya GES. After that, a second high-tension electric power line will be built and connected directly to the nominal voltage. After the completion of road construction, the first line will also be changed over to 220 kV.

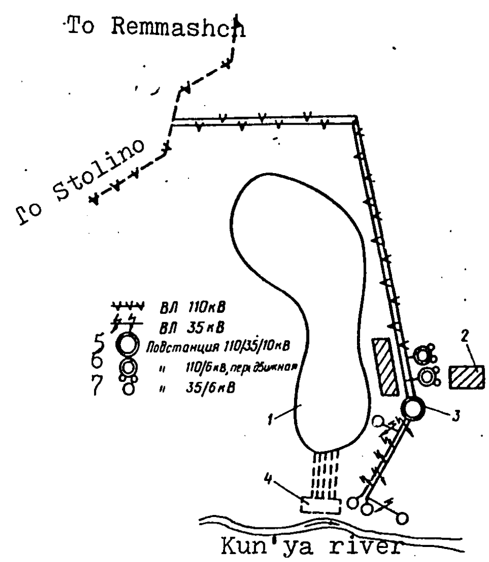

Fig. 4 Layout of electric power supply to the Zagorskaya GAES construction site.

1-Upper accumulation basin; 2-Construction base; 3-Primary step-down substation; 4-GAES building; 5-Substation; 6-Mobile substation; 7-Substation

Throughout the entire preparatory period (up until electric power is delivered from the system) the electric supply to the construction site will be accomplished through 2x2500 kW gas-turbine installations and a 1000 kW diesel electric power plant, which will remain as a load reserve in the future. However, it must be noted that the limited capacity of the on-site electric power sources has, at the present time, a negative effect on the pace of construction operations during the preparatory period.

On the whole, the electric power supply layout for the construction of the Boguchanskaya GES, developed with an accounting for construction experience obtained at the Bratsk and Ust'-Ilimskaya GES's and other Siberian hydraulic developments, may be considered optimal.

The Zagorskaya hydro-accumulation electric power station on the Kun'ya river (Moscow oblast) is located in a region heavily saturated with electric power nets. The maximum power required for construction amounts to 22,000 kW (fig. 4).

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ELECTRIC POWER AND POWER EQUIPMENT

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IMPROVED SUPPORTS FOR ELECTRIC POWER LINES

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 11, Nov 79 pp 48-51

[Article by Engineer L. L. Peterson and Candidates of Technical Sciences A. I. Kurnosov and Yu. A. Gabliya: "Methods of Improving the Design of Supports for High-Tension Electric-Power Lines of 500 kV Voltages and Higher"]

[Text] A broad program for placing electric power station capacities into service and, consequently, for constructing high-tension electric power lines of 500 kV and higher voltages has been planned at the USSR Minenergo. Results of calculations show that, in the future, the delivery of the output of only the country's largest electric power stations will require that several thousand kilometers of 500-1150 kV high-tension power lines be built. These will be essentially electric transmission lines that will link the country's European section to the Ekibastuz power complex and the Surgut GRES. The electric transmission lines will cross highly swamped territories as well as regions of perennial permafrost. The regions through which the high-tension lines in question will pass are characterized by underdeveloped roads and railways.

The selection of design solutions for the supports and foundations of the 500 kV and higher power lines is determined by both the voltage of the electric transmission line and the area through which it passes. Taking into account the over-all engineering evaluation and the acquired design experience, it is expedient to utilize guyed supports as intermediate supports. Under special conditions it is possible to utilize free-standing supports in traditional strut or stayed-strut configurations [1].

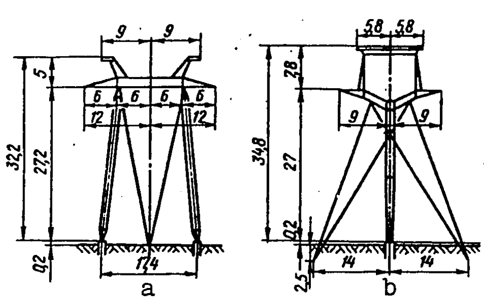

Fig. 1 Supports for 500 kV high-tension lines.

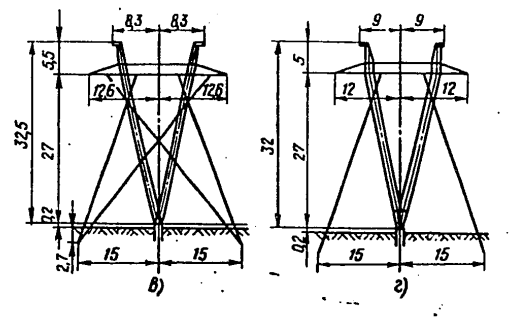

Fig. 1 Supports for 500 kV high-tension lines.

Supports with a rigid cross member. Guyed portal-type supports (fig. 1a) are among the most common supports of the stayed design. These are the basic types of supports for 500 kV high-tension electric power lines. To their shortcomings one must add the complexity of the installation on inclines. In this case the supports must be made from an assembly of sections, the lengths of which are determined by the normalized elevation of the base. Within each interval the ground rise is eliminated by levelling. Under such conditions it is expedient to utilize guyed supports with a single point of support on the base.

Taking into account experience in utilizing portal-type supports on 500 kV high-tension lines, similar designs were developed for 750 kV high-tension lines also. Up until 1978 the slope adopted for struts in the portal-type supports was equal to 1:10. At the present time the slope has been increased for 750 kV high-tension lines and amounts to 1:5. In addition to this, an increase is envisioned for the distances between the loaded (leeward) struts and the anchor plates in the plane of the portal. As a result, the axial stress in the loaded strut and, correspondingly, the loads on the foundation (for the line's normal operating conditions) decrease. The cross member of such supports has a broken contour (rising at the center point), thanks to which the length of the struts is shortened with comparatively small increases in the length of the cross member (along the axis). It must be noted that the design of the cross members becomes, at the same time, somewhat complicated. The mass of such supports 35 meters long averages 10 tons.

To the shortcomings of the guyed portal-type supports one must also attribute a rather great dependence of the stresses in the leeward strut on the magnitude of the deformation of the support in the plane of the portal. According to a constant schedule, the wind and weight loads which lead to bending of the leeward strut act in opposing directions. When there are externally applied loads, the strut is deformed and the slope of the leeward strut decreases. With a practically constant wind load, the load component for the weight decreases. This leads to a deterioration in operating conditions for the strut. This peculiarity of the portal-type support with a strut slope of 1:5 leads to limitations on moving the bases to which the guy lines are attached.

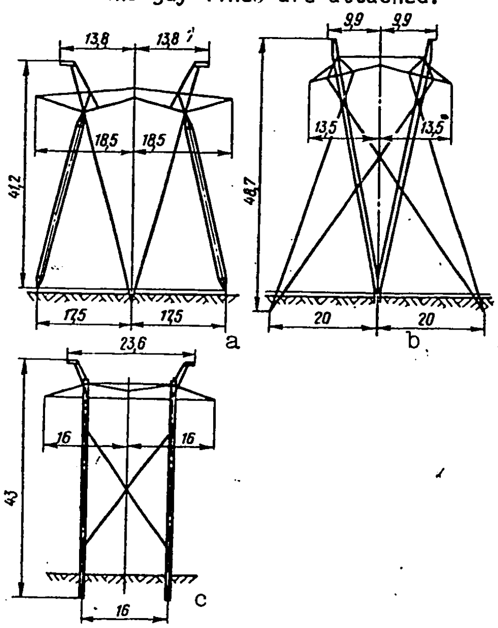

Fig. 2 Supports for 750 kV high-tension lines.

We have managed to eliminate the shortcomings just noted in the design of the "Chayka" ("seagull") supports (fig. 1b). Metal is used more efficiently in this support (with the wind from any direction, the same strut is loaded). Chayka-type supports, which are intended for 500 kV as well as 750 kV high-tension lines, are characterized by good economic indicators. Electric transmission lines that cross extremely rugged terrain are the most effective areas of application. In economically developed areas, where the extent of the anchoring strip is not great, the use of supports of great fixed height is inefficient, since utilization of the span capacity decreases at the same time. When Chayka-type supports are used, this problem is solved by switching out sections of the support struts.

Builders explain objections to the application of this type of support by the complexity of installing the center phase. Familiarization with the method in which a helicopter is used to string the conductors and the extensive introduction of a method in which the conductors are strung while under tension make it possible to eliminate this difficulty.

At the present time, the problem of installing the third phase can be solved entirely satisfactorily through the application of V-shaped supports. There exist two essentially different solutions for this support: the domestic design with split stays (fig. 1c)and a design with four individual stays, developed in Canada (fig. 1d). In operational characteristics and the standards for use of materials, the latter design is similar to the guyed portal-type support. The difference consists only in the disposition of the working elements in the wind stream: in the Canadian design, under the influence of loads during normal operating conditions, the windward strut and the stays pertaining to it serve as the working strut, while in the portal-type design it is the leeward strut. An indisputable advantage of the V-shaped supports over the portal-type is the feasibility of their installation on unlevelled construction platforms for electric transmission lines that traverse sloping terrain. A shortcoming of such a support (in comparison with the portal-type) is the complexity of stringing the center phase conductors and the great horizontal stresses on the base. Under V-shaped supports the base is set vertically. The horizontal stress on such a base is the sum of the resultant horizontal stress components in the windward N_{sw} and leeward N_{sl} struts plus half of the wind pressure on the struts, that is

$$P=(N_{sw}-N_{sl})\sin\alpha+\tfrac{1}{2}(P_{sw}+P_{sl}),$$

where P_{sw}, P_{sl} is the full pressure of the wind on the windward and leeward struts; α is the deviation of the strut from the vertical.

When designing V-shaped supports, the weight-distributing effect of the windward strut's own mass is usually not taken into account, since it is not constant (it decreases with an increase in the overall deformation of the support). In portal-type struts, the axes of the struts and the bases upon which they rest are coincident (there is no component of axial force nor a perpendicular axis for the base column). The technical-economic

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indicators of the V-shaped support of Canadian design and of the guyed portal-type support are approximately the same.

In the V-shaped strut with split stays the metal is used more efficiently than in the support of Canadian design (struts with split stays are loaded approximately the same). When selecting points on the cross member to which the stays will be affixed, the horizontal force on the compressed base must be brought to a minimum which is determined by the overall deformation of the support and the varied distribution of stresses under normal operating conditions in the presence or absence of an ice crust. The stresses on the anchoring bases in the domestic support are also somewhat lower than those on the bases of the support of Canadian design.

In the designs under consideration, the point where the stays are fastened to the support is located on the cross member. This leads to an additional loading on the cross member elements and to an increase in the expenditure of metal. Therefore, the application of V-shaped supports with split stays is efficient when the horizontal stresses and heights of the supports are great.

It must be noted, however, that due to the small cross sections of the upright struts, the V-shaped supports with split stays which have been developed can not be extensively employed on 500 kV and less high-tension lines (due to technological, transportation and other limitations). Such supports (fig. 2b) are expedient to use on 750 kV and greater high-tension lines, since this makes it possible to decrease (in comparison with the portal-type support) the expenditure of materials and to reduce their cost. To the support's shortcomings one must add the relatively large dimensions of its installation platform.

In many cases, reinforced concrete portal-type supports with internal couplings (PVS's), manufactured from cylindrical pipes 20 m long and 800 mm in diameter (fig. 2c), are expedient for 750 kV high-tension electric power lines. Each strut of the support is 40 m long and is constructed from two pipes connected with the help of a flanged junction. The cross member is metal. Its configuration is the same as those in the internally coupled portal-type supports for 500 kV high-tension lines. A platform of considerable dimensions is not required for the installation of internally coupled portal-type supports on 750 kV high-tension lines. These supports are intended primarily for electric transmission lines constructed in those regions of the country in which short anchoring strips and considerable areas of worked land are typical.

It is necessary to add to the shortcomings of the 750 kV internally coupled portal-type support the presence of the flanged junction and its considerable mass (more than 20 tons). In order to connect the strut sections on station, it is necessary to have equipment to insure the alignment of their axes, and for the installation of the assembled strut into the bored foundation pit, a special crane is needed.

Supports with a guy-line cross member. At the present time there is an absence of methods that would allow one to determine the parameters of a support with a guy-line cross member. In addition to the greater economic impact, they would also insure the mechanical reliability and stability of the electric transmission line. The basic difference between portal-type supports with guy-line cross members and supports with the usual cross members is great flexibility in positioning the attachement points for the insulator chains.

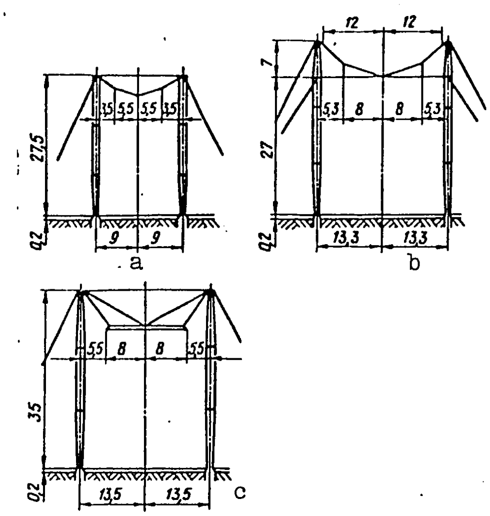

Fig. 3 Versions of supports with flexible cross members.

Supports with a guy-line cross member, as a rule, consist of two knife-edge struts and a system of flexible stays which ensure the working position of the struts and the support of the conductors. The struts may be vertical or inclined. In the last case, the width of the right of way and the dimensions of the support's installation platform are now being successfully reduced. The layout of the support itself depends primarily upon the configuration of its flexible member.

One of the design variations for supports with guy-line cross members is a design with four guy lines and one spanning stay for suspending the conductors (fig. 3a). In such a support the vertical stresses are transmitted fully to the horizontal stay. As a result, this stay has the shape of a string polygon. For the distribution of installation stresses an additional horizontal connector is usually stipulated. It serves as a third stay for both struts. In addition, it decreases the shift of the struts' pivot points with respect to the attachement points on the flexible stays.

In the model under consideration, material is sufficiently economically employed and the separate elements of the support work relatively precisely. A shortcoming is the considerable horizontal and vertical movement in the attachment points for the insulator chains. The horizontal displacements of these points in the plane of the struts lead to a decrease in the insulating distance between the conductors and the strut. Therefore, it is necessary that the distances employed between the outer phases and the uprights take into account these displacements. When there is a non-simultaneous release of ice-crust from adjacent conductors the string polygon is deformed. The attachment points for the phase whose conductors have been freed from the ice rise, while the attachment points for the phase with ice-covered conductors drop. The most unfavorable operating conditions for high-tension lines arise when ice is dropped from the conductors of the outer phases and is retained on the conductors of the center phase.

A substantial reduction in the horizontal displacements of the insulator chain attachment points can be achieved through the use of an alternative design, depicted in fig. 3b. In this arrangement there also are two spanning stays: an upper stay, in the shape of a string polygon, and a lower stay, which is horizontal. They are fastened to the struts at various points. The upper spanning stay absorbs only the vertical stresses, which are then transmitted through vertical mountings. Stresses created by wind pressure on the conductor, as well as horizontal stresses acting along the electric power transmission line are transmitted to the lower stay. The lower spanning stay is made with a minimum of slack. Displacement of the insulating chain's attachment points in the plane of the struts under the influence of wind stresses is not great and exerts practically no influence on the approach of the outer phases' conductors toward the struts. The displacement of these points along the line is considerably less than in the preceeding design. However, under the influence of longitudinal horizontal stresses considerable forces develop in the stay under consideration.

Since the horizontal forces in the upper and lower stays are transmitted at various points, two stay arrangements are possible for this support: one- and two-level. In the one-level configuration the strut is supported by stays at one of the cross-stay attachment points determined from a calculated analysis. In addition, the windward strut, besides the axial compression and wind-distributed forces, also absorbs a horizontally concentrated force transmitted at the attachment point of the second stay. The expenditure of metal on struts made in this configuration can turn out to be considerable.

In the two-level configuration the stays are attached at both points. The operating conditions of the windward strut are relieved, however, the stay arrangement, as a rule, are higher than those of a single-level support.

In order to avoid the two-level stay arrangement, arrangements for the cross-bar portion are proposed, in which transverse fixing of the insulator chain's attachment points is provided for through independent tie pieces (fig. 3c). In this case, each phase is attached to the struts with the help of a system of two inclined stays. All three systems are combined with the help of a horizontal element which can be flexible or rigid. The upper ends of the inclined stays are attached at the same angles as the guy lines. The upper horizontal stay, through which the horizontal components of the installation forces in the guy lines, as well as those of the forces created by longitudinal stresses, is attached to the upper ends of the inclined stays. Through the upper horizontal stay the stresses from the wind pressure on the leeward cable, strut and guys are transmitted to the windward system. In this support, the longitudinal horizontal displacements of the isolator chains' attachment points are considerable.

Designs of supports that utilize elements made of insulating material instead of steel cable for the spanning stays are promising. In this case, the conductors may be fastened directly to the spanning system. The elimination of the supporting isolating chain makes it possible to sharply reduce the passive altitude of the support, to decrease the expenditure of materials and, correspondingly, the cost for the construction portion of the lines (the cost of insulation will increase).

The creation of such designs is essentially possible with the application of common porcelain or glass insulators. The application of glass and plastic insulators for the spanning stays is more expedient, however. These materials possess great strength and low density, which is particularly important for similar designs. The creation of supports with insulating cross members must be preceeded by a comprehensive analysis of electric transmission line operation with such supports and the development, on this basis, of the technical specifications for the design.

Anchor supports. The most efficient anchored angular supports for 500 and 750 kV high-tension lines are the free-standing three-strut supports. The struts of such supports do not depend on each other: the conductors of the corresponding outer phases and the lightening-arrestor cable are attached to tne outer struts, while only the conductors of the center phase are attached to the center strut (fig. 4). Each strut is a solid quadrahedral girder of pyramid shape. Below the attachment point for the conductors all three struts are usually made to be identical. In those cases, however, when the lightening arrestor cable is used for high-frequency communications and its cross section is great, and stresses due to the cable increase correspondingly, such a design decision can be inefficient, since it will lead to a substantial overexpenditure of materials.

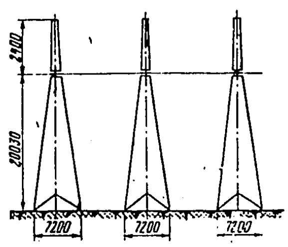

Fig. 4 An anchored angular support.

The struts' optimal parameters are determined taking into consideration the character of the soil and the controlling stresses. Results of calculations show that the optimal height for these supports is that height which is determined by the insulating distance to the earth and the distance necessary for positioning the guide stub. The application of supports of great height is expendient only in special cases, when the overall criteria for optimization are fixed.

The technical-economic indicators of intermediate supports are given in the table.

It can be seen from the date in the table that the expenditure of metal for supports used at present varies. This confirms the expressed opinion that some designs are insufficiently developed. The portal-type and V-shaped supports with split stays for 750 kV high-tension lines have higher indicators in comparison with foreign types. According to data for materials [2] the expenditure of metal for supports of ordinary design comes to 31 tons/km. For domestic portal-type intermediate supports the expenditure of metal is equal to 23.2 tons/km, and for the V-shaped supports with split stays it is 20.5 tons/km.

Supports with guy-line cross members have higher indicators. Their application on one of the 735 kV lines in Canada made it possible to reduce the expenditure of metal by 19 tons/km. A technical-economic analysis, done by the Energoset'proyekt Institute's North-West Divison, on the extent of experimental planning showed that the expenditure of metal during installation of supports with flexible cross members on 750 kV high-tension lines is approximately the same as in Canada, while on 500 kV and 1150 kV lines it is 14.5 and 32 tons/km, respectively.

1 Тип опоры	2 Напряжение ВЛ, кВ	3 Климатический район: 4 по гололеду	3 Климатический район: 5 по ветру	6 Фаза	7 Грозозащитный трос	8 Высота, м	9 Габаритный пролет, м	10 Средний пролет, м	11 Количество опор на 1 км*	12 Масса опоры, т	13 Расход металла (стали) на опору, т/км
				14 Примененные опоры							
16 Портальная		II—IV	III	5Ac240/56	4Ac70/72	35	450	423	2,365	12	26(10,8)
		II—IV	III	4Ac500/64	4Ac70/72	35	480	433	2,31	12,48	26(10,8)
		III—IV	IV	4Ac400/93	2Ac70/72	32	410	361	2,772	16,53	42,6
		III—IV	IV	4Ac400/93	2Ac70/72	32	440	362	2,765	13,99	35,7
		III—IV	IV	4Ac400/93	2Ac70/72	35	400	347	2,89	14,5	39
		III	III	4Ac500/64	3Ac70/72	35	450	406	2,46	13,07	29,5
		IV	IV	4Ac500/64	2Ac95/141	35	475	411	4,43	13,9	31
		IV	III	4Ac500/64	2Ac70/72	35	415	375	2,67	13,2	32,6
17 V-образная с расщепленными оттяжками		III	III	5Ac240/56	2Ac70/72	38	520	458	2,18	12,9	25,6
				15 Рекомендуемые опоры							
18 Портальная на оттяжках	750	II—III	III	5Ac330/27	4Ac70/72	35		442	2,37	10,7	23,2(10,8)
19 V-образная с расщепленными оттяжками		II	III	5Ac300/39	2×2Ac70/72	38	535	465	2,15	10,56	20,5(8,05)
20 Портальная с вантовой траверсой		II	III	6Ac300/39	2×2Ac70/72	36	540	486	2,06	9,4	17,5
21 V-образная с расщепленными оттяжками		II	III	8Ac400/51	2×2Ac70/72	50	565	508,5	1,97	27,8	49,1
22 Одностоечная с расщепленными оттяжками		II	III	8Ac400/51	2×2Ac70/72	50	565	508,5	1,97	23,2	41,1
23 Портальная с вантовой траверсой	1150	II	III	12Ac300/39	2×2Ac70/72	45	525	472,5	2,12	21,2	40,6

*With the conventionally utilized identical number of anchored angular supports (0.2 supports/km)

1. Type of support
2. Line voltage, kV
3. Climatic region
4. According to icing
5. According to wind
6. Phase
7. Lightning-arrestor cable
8. Height, m
9. Overall span, m
10. Average span, m
11. Number of supports per km
12. Mass of support, tons
13. Expenditure of metal (steel) per support, tons/km
14. Supports utilized
15. Recommended supports
16. Portal-type
17. V-shaped with split stays
18. Guyed portal-type
19. V-shaped with split stays
20. Portal-type with guy-line cross member
21. V-shaped with split stays
22. Single strut with split stays
23. Portal-type with guy-line cross member

CONCLUSIONS

1. On 500 and 750 kV high-tension electric power lines the use of portal-type supports and V-shaped supports with split stays is recommended. A more concrete area for their application is determined depending upon requirements due to the lay of the land.

2. For super high-tension lines and primarily for 750 and 1150 kV high-tension lines, supports with guy-line cross members, differing by reduced expenditure of metal (30-35 percent less than stayed supports of ordinary construction), are recommended. The economic impact from their introduction will come to approximately 150,000 rubles for each 100 km of line. Three-strut free-hanging supports of minimal height, determined by the ground clearance, are suggested as anchored angular supports.

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FUELS AND RELATED EQUIPMENT

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NEW OIL-WELL COMPLETION METHOD DESCRIBED

Moscow BURENIYE in Russian No 12, Dec 79 signed to press 4 Jan 79 pp 24-25

[Article by A. U. Sharipov, V. N. Polyakov and R. R. Lukmanov (BashNIPI-neft' [State Scientific-Research and Design Institute of the Petroleum Industry of the Bashkir ASSR]): "A New Method for Well Completion"]

[Text] Oilfield experience indicates that the methods now used to prepare the well bore for casing and to isolate beds do not always meet the constantly changing hydrodynamic conditions for developing the deposit. Building a cement ring 22-34 mm thick is not always adequate for reliable isolation of beds and conservation of resources.

The development of water and oil accumulations became more difficult at the Urals-Volga deposits. Thus, water encroachment occurred in 27 percent of Arlan deposit wells, in cross-sections of which there are beds with an oil-water contact (VNK), as a result of lack of sealing capability of the cement ring, and 54 percent of the wells are encroached by bottom water [1].

The method most widely used for dealing with bottom-water flow in cased wells is the installation of waterproof screens in the VNK zone or in the water-bearing portion of the bed. All the isolating work is done with existing or specially created filters. Despite the use of various methods and materials and the expenditure of large resources, the technical and economic effectiveness of the isolating work is still low. At Bashkiria's deposits, the success rate for work to eliminate circulation in the annular space is 49 percent, and for work to isolate bottom water it is 30 percent, of the total amount of this work [2].

Because of this, it is desirable, in order to raise the reliability in isolating beds and effectiveness in developing water-and-oil formations, that the water-bearing beds (the potential encroachers) be isolated prior to casing the well with the casing string.

Isolating the potential water encroachers beforehand will make it possible:

1) To preclude or reduce interaction of the well with the bed, creating favorable conditions for raising the plugging agent to a great height and for forming a reliable cement ring;

2) To increase the resistance of the flow of reservoir water to the well's filter, to raise the effectiveness of seal when isolating beds by redistributing the pressures on the walls of the well and by reducing the effect of major pressure differentials between beds; and

3) To block off the bottom water prior to casing the well.

In 1977-1978 the water-bearing portion of bed No 6 at five Arlan deposit wells was isolated in an open bore prior to lowering and cementing the casing string. Bed No 6 is the main source of water encroachment at this deposit's wells [3].

Preparation of the interval of occurrence of the productive horizon and isolation of the water-bearing bed by the method developed by BashNIPIneft' calls for:

1) Removal of the mud cake from the well's walls;

2) Selective isolation of the water-bearing bed and injection of a plugging solution throughout its thickness with a view to creating a screen with the required radius; and

3) Raising to the technologically required level the sealing effectiveness and the resistance to hydraulic destruction of the isolated part of the well bore.

The technology of the work is as follows. The position of the VNK in the well is determined in accordance with the results of geophysical studies, and the target for isolation of the bed's waters and the place for installation of the packer, which is lowered on the drill string, are selected. The instrument's configuration includes: a guide shoe, a valve, a water jet, a packer with a rest on the bottom, and the drill string.

After the tool descends to the prescribed depth, the part of the well bore to be isolated is treated with the water jet, to remove the mud cake. After the packer is installed, plugging material is pumped into the water-bearing bed. Water glass, polyacrylamide solutions and cement and clay suspensions are used as such materials. Up to 6 cubic meters of polyacrylamide solution and up to 12 cubic meters of clay solution were pumped into the water-bearing part of the beds of test wells. The final pressure for injecting the plugging-material solution was 15 MPa, which is 2-3 MPa higher than the strength of the well bore against hydraulic destruction during testing for injectivity. In all the test wells the cementing solution was raised to the well head. The test wells were successfully mastered and introduced into operation.

The time taken for the work to isolate the water-bearing layer did not exceed 6-8 hours. The principal time expenditure was associated with the round trip of the tool and preparation of the plugging material. Later, as the method is improved, time expenditure for isolating work can be greatly reduced.

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