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Rapid Erection Method for Steel Stacks

Méthode de montage rapide pour des cheminées en acier

Schnellmontageverfahren für Stahlkamine

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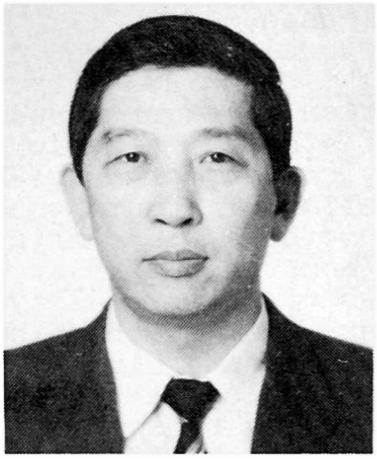

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SUMMARY
This paper describes the influence of a stacks structural parameters on erection labour expenditure, the estimating procedure of stacks' adaptability for erection, technical-and-economic index of different erection methods, erection-site-process of stack hoist squeezing out with tackle block equalizing system.

RÉSUMÉ
L'article traite de la relation entre les caractéristiques techniques d'une cheminée et les frais en personnel pour le montage, de l'évaluation du type de montage approprié sur la base d'indices technico-économomiques. Il présente le montage de la cheminée selon la méthode de la poussée vers le haut au moyen de vérins.

ZUSAMMENFASSUNG
Der Artikel behandelt den Einfluss der technischen Eigenschaften von Stahlkaminen auf die Personalkosten für die Montage, die Evaluation der besten Montagemethode auf Grund verschiedener technisch-wirtschaftlicher Bestimmungsgrössen, sowie die Montage der Stahlkamine nach der Methode des Taktaufziehverfahrens mit Takelwerken.

Steel tower type exhaust stacks in the industrial construction present a separate group of tower structures characterized by a specific design and certain difficulties of erection especially at operating plants and those under reconstruction. Intensification and growth of ferrous and non-ferrous metallurgy, power, chemical and some other industries caused an increase of exhaust stack construction in order to protect the environment from noxious and corrosive gases. That is why shortening duration of stacks erection, raising labour productivity and improving safety of works at the construction site became matter of scientific and industrial significance.

Great variety of structurally-arranged designs of steel frame exhaust stacks of height up to 200 m brought to life numerous methods of their erection. That provided additional difficulties in application of standart erection rigging and equipment and questioned the rationality of large-block erection. In spite of permanent modernization of traditional build-up and turning around hinge erection methods their major drawbacks remained the same: large amount of mounting works at height, use of expensive equipment, difficulties of joint quality control, necessity of special safety measures, limitation of height of stackswhich are to be erected by turning around hinge method-not higher than 100...120m. The development of new hoist squeezing out methods with tackle block equalizing system entailed changes of stacks' structurally-arranged designs.Different project firms worked out steel stack designs without taking into consideration their adaptability for erection because of simple engineering methods of estimating, such points were not yet elaborated. Structures of analogous stacks possessed different numbers of structural elements,different masses, the joints of the stacks differed in quantity of bolts and masses of weld metal. That was the reason why labour expenditure on construction sites differed 1.2...1.8 times for analogous stacks erected by the same method and with the same equipment.

Researches conducted in VNIPI Promstalkonstructsia on the basis of 50 stack designs permitted to determine the influence of stack structural parameters on the labour expenditure and express this dependance by multiple regression equations [1]:

$$T_1=-2.276+0.267M+0.197N_{el}+0.007N_b+0.051G \qquad (1)$$

$$t_{bl}{}^i=-0.339+0.239M+0.163N_{el}+0.018N_b+0.09G \qquad (2)$$

where : T_1-labour expenditure of stack pyramidal part assembly, man-day;

$t_{bl}i$ - labour expenditure of assembly of stack prismatic part i - block, man - day;

M - mass of corresponding part of stack frame, ton ;

N_{el}- number of dispatched elements, pcs ;

N_b - number of bolts in assembling joints, pcs ;

G - mass of weld metal in joints , kgs ;

Multiple determination ratio of equation (1) is equual to 99.34 and equation (2) - 98.34. Labour expenditure on assembly of stack prismatic part T_2 is determined by the formula :

$$T_2 = \sum_{i=1}^{n} t_{bl}i \qquad (3)$$

Thus the total labour expenditure of assembly works is determined by summation T_1 and T_2. The obtained data may be compared with the indexes of the basic variant. In that way it is possible to choose a profitable type of stack structurally-arranged design. To execute the procedure it is necessary to calculate the stack weight (mass), number of dispatched elements, bolts in assembling joints as well as mass of weld metal. To simplify the determination of labour expenditure on assembly works of pyramidal and prismatic parts blocks nomographs are developed on the basis of multiple regression equations (1) and (2). One of them is shown in fig. 1.

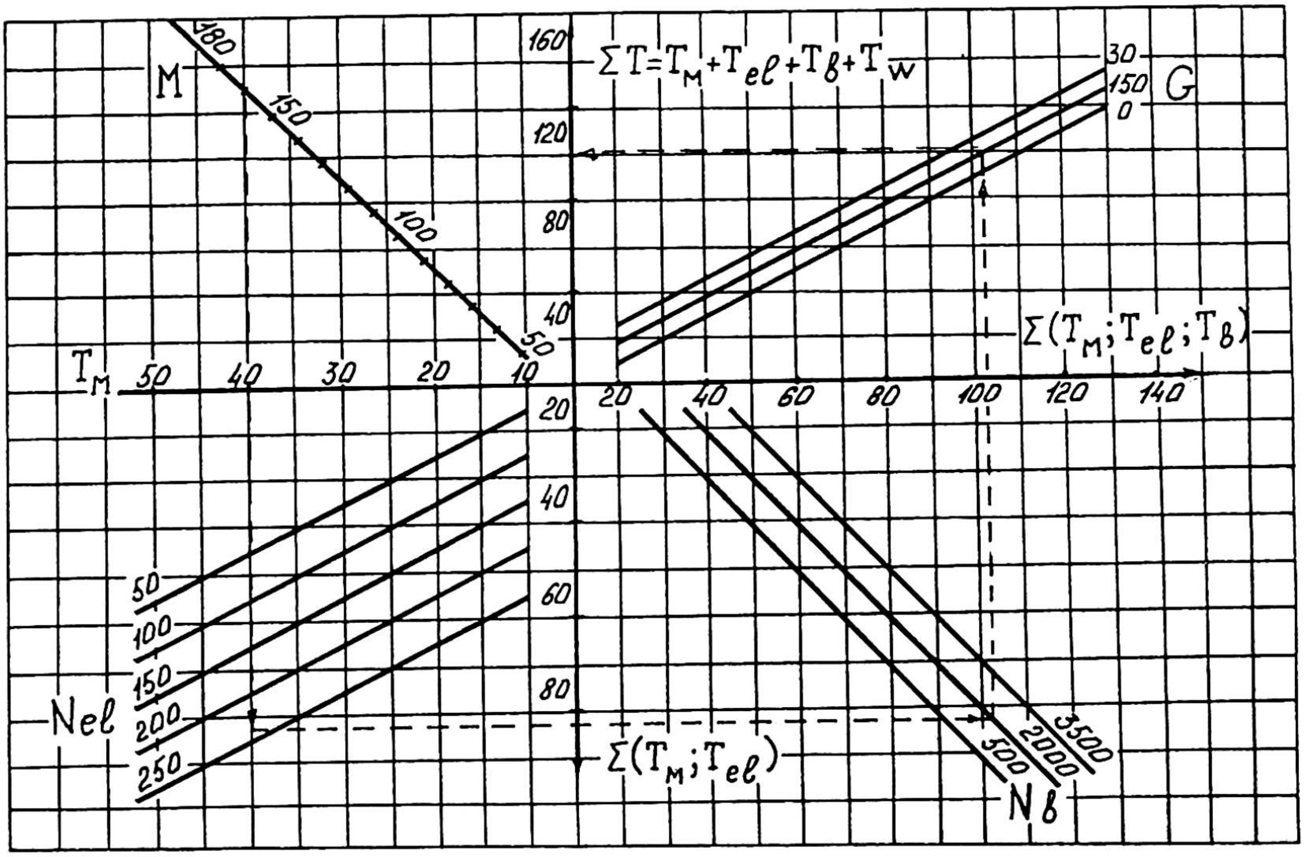

Fig 1. Determination nomograph of stack pyramidal part assembly labour expenditure.

The procedure of quantity estimation of stack design adaptability for erection was used for choosing profitable standard structurally-arranged designs of exhaust stacks with heights of 90, 120, 150 and 180 m. Such designs permitted to reduce the value and number of structural parameters. That provided reducing labour expenditures to 12...15% of traditional structural designs indexes. For example, using in structure triangular lattice instead of cross or rhombus one permits to decreas erection labour expenditure to 1.6 times. The rewiew of home and foreign experience of stack design and construction as well as the analysis of published original sources showed a wide range of variation of labour expenditure and duration of erection works. Determination of effective methods of stack erection if based on separate criteria does not always correspond to real practice. That is why technical-and-economic analysis of

the most wide spread stack erection methods in the USSR was carried out by means of multifactors estimation procedure. The procedure includes expert and quantity estimates of erection works safety level. Safety level is determined from time of mounting works at height accounting for probabilistic influence of traumatic factors.
Analysis of technical-and-economic indexes of stack erection processes showed the method of stack squeezing out with tackle block equalizing system in comparis on with traditional methods of stack erection (table 1) ensured the following advantages: raising labour productivity to 25...53%, shortening erection time to 18...31% (duration of erection), decreasing erection cost to 23...41%, improving erection works safety level to 45... 120% and significant improvement of working conditions at the expense of carrying out erection process at low height on stationary scaffolds, raising quality control reliability of mounting joints fulfilment, creating production conveyer line of assembly and installation of stack prismatic part blocks, reducing volume of mounting works height to 2...2.5 times, exception of application of expensive and deficit erection rigging and equipment, etc. [2,3].

Indexes	Methods of erection: Build up methods: self-claiming crane on the cylinder	self-crawling gantry	tower crane with attachments	Hoist: squeezing out with tackle block equalizing system	Turning around hinge
Mass, t	253	255	253	265	262
Cost, %	79	100	118	77	118
Cost of 1 ton of mounted steel structure, %	80	100	119	74	114
Duration of erection, %	131	100	139	85	107
Labour expenditure of erection works, %	107	100	134	76	106
Output, %	93	100	75	137	98
Safety level of erection works, %	85* 81**	100* 100**	150* 172**	200* 261**	185* 209**

* - expert estimate [4]
** -quantity estimate by VNIPI Promstalkonstructsia procedure

Table 1. Technical-and-economic indexes of erection methods.

Video-recording equipment with automatic data processing were used to analyze actual labour expenditure of different assembly and installation processes, operation elements and labour techniques.

That permitted to work out an optimum model of assembly and installation of steel stacks structures. Introduction of such models reduced labour expenditure of erection works to 10...12%.
The results of the conducted researches allowed to improve the erection-site-process of stack hoist squeezing out method, which contained:
- standard assembly of spatial frame blocks with exhaust cylinder blocks of the equal height on special stand;
- block on the stand transportation from assembling site to the place of installation by rails;
- connecting the block to the structures of the stack prismatic part have been put into position before;
- hoist squeezing out of stack prismatic part with exhaust cylinder by means of tackle block equalizing system at the block's height;
- lowering the stand on the rails and transporting it back to the blocks assembling site to assemble a new block.

Such erection-site-processes are repeated until squeezing-up part of the exhaust stack reaches its design elevation. Simultaneous installation of stack steel frame with exhaust cylinder permitted to reduce labour expenditure of erection works to 7...9% additionally.

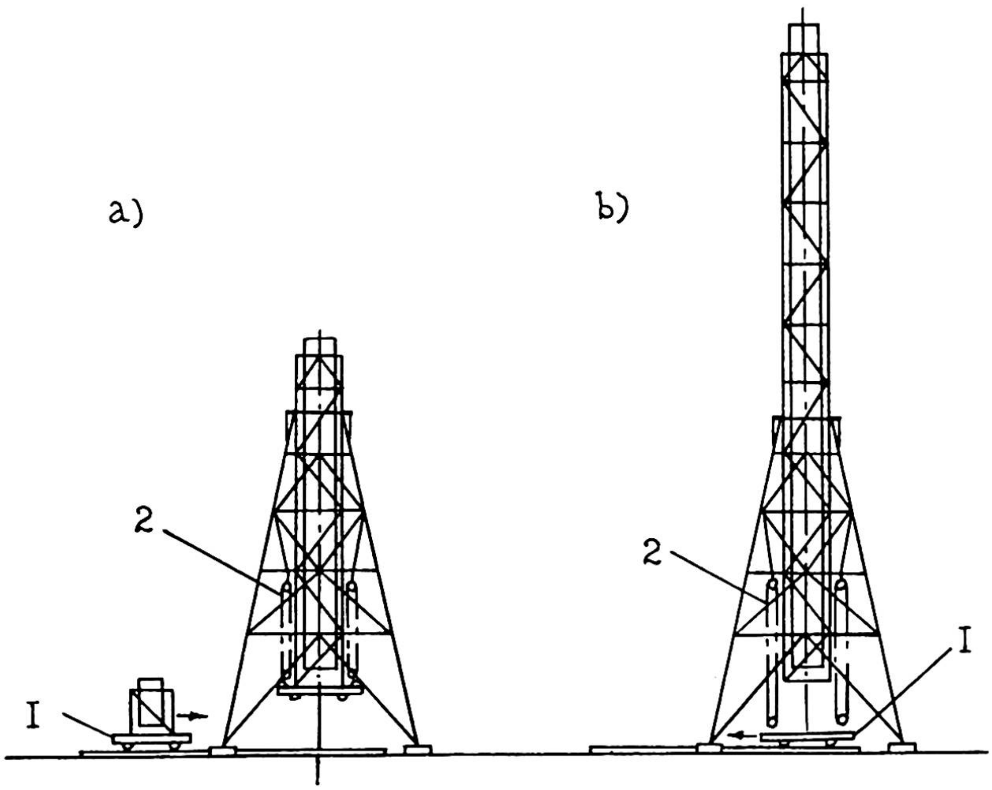

Fig.2 Scheme of erection: a -first step of squeezing out; b - intrmediate position; 1 - stand with block on; 2 -tractive tackle block.

Tractive tackle block system consists of separate tackle blocks Their quantity is equal to the number of stack's sides. Special equalizing system includes dynamometers which are provided for control forces in the ropes going to the winches. There are guiding devices inthe pyramidal part of stack to stabilize the pri-

zmatic part during squeezing out.
Experience of designing and erection of different types of stacks was generalized and specifications were formulated. They permitted eliminating unwarranted multiformity of stack types as well as multimodification of ineffective erection methods and to work out new structurally-arranged designs of exhaust stacks. Erection of tower structures of such designs with due regard for the above mentioned developments permitted to reduce labour expenditure and duration of erection in 1.5...1.7 times.

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