Rapid Erection Method for Steel Stacks

Méthode de montage rapide pour des cheminées en acier

Schnellmontageverfahren für Stahlkamine

V. G. KIM
Civil Engineer
VNIPI Promstalkonst.
Moscow, USSR

V. G. Kim, born in 1941, graduated from the Moscow Civil Engineering Institute in 1964. Now he is the head of a department and responsible for the design of heavy industrial buildings.

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] :

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

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

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 :

$$T_2 = \sum_{i=1}^{n} t_{bl}i \tag{3}$$

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 assembl-
ing joints as well as mass of weld metal. To simplify the deter-
mination 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
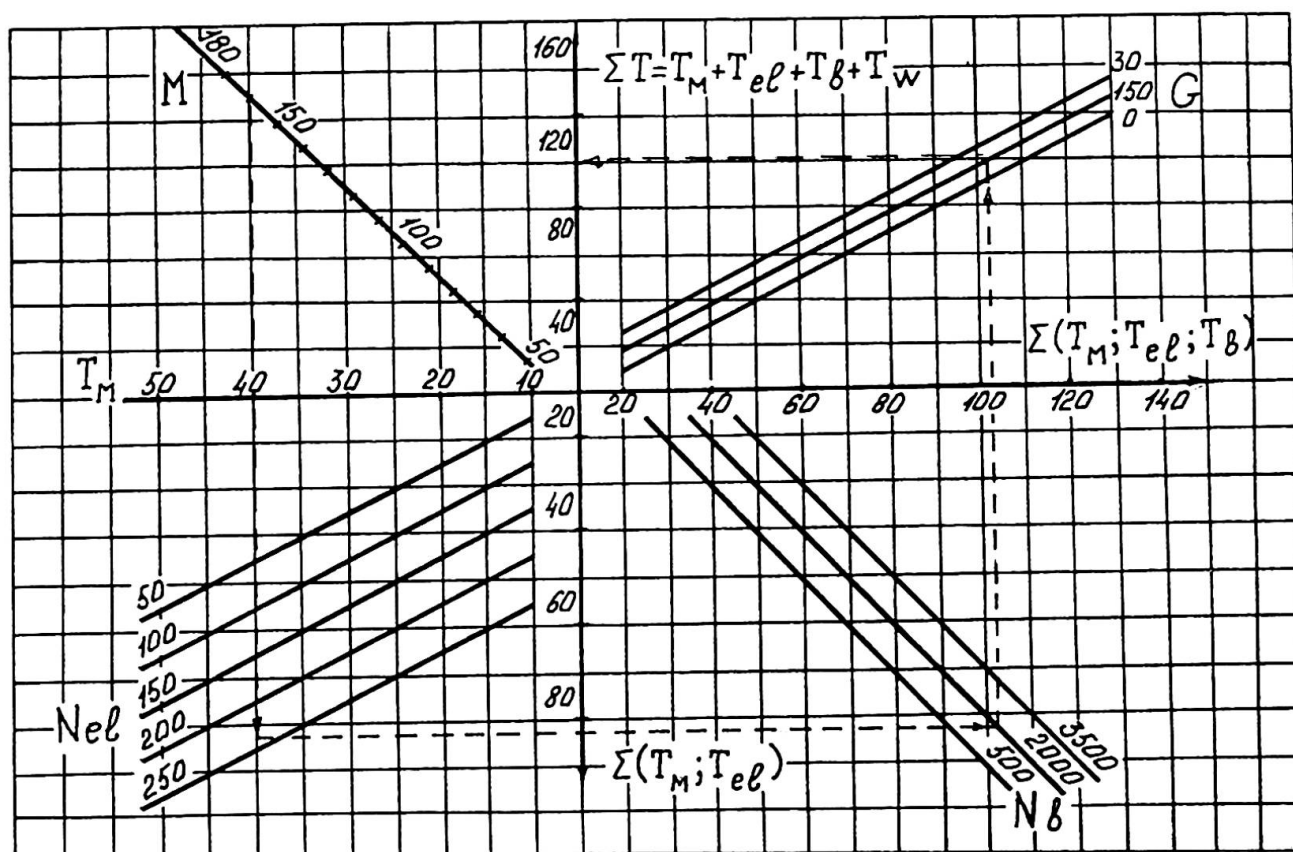in fig. 1.

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 structural-
ly-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 | | | Hoist squee-zing out with tackle block equa-lizing system | Turn-ing around hinge |
	self-claiming crane on the cy-linder	self-craw-ling gantry	tower crane with attach-ments		
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 in-
stallation 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 cylin-
  der 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% additio-
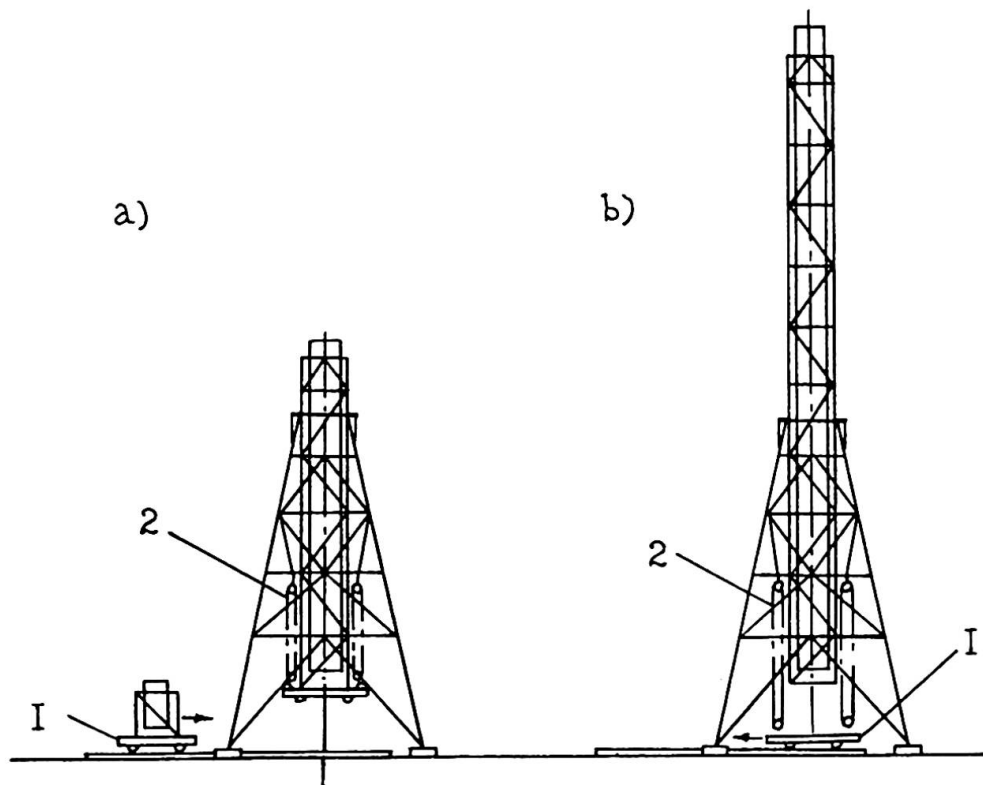nally.

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 guid-
ing 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 permit-
ted 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.

REFERENCES

1. KIM V.G., FRENKEL V.M. Metodika otsenki montazhnoi tekhnologitch
   nosti vityazhnikh bashen po kriteriyu trudoemkosti/ Montazhnie i
   spetsialnie raboti v stroitelstve, 1986.N 8, pg. 22-24.

2. KIM V.G., VISCHINIS A.D. Montazh vityazhnoi bashni podraschivaniem
   na Kedainyajskom khimzavode,-M. 1986. - pg. 15-19.-/Montazhnie
   i spetsialnie stroitelnie raboti. Seria YII, Izgotovlenie
   metallicheskikh i montazh stroitelnikh konstructsi /TSNTI Min-
   montazhspetsstroya SSSR; vipusk 3/

3. KIM V.G. Povishenie effectivnosti montazha vityazhnikh bashen-
   trub.- M., 1987. - 44. -(Montazhnie i spetsialnie stroitelnie
   raboti. Informatsionnoe obespechenie otraslevikh programm i
   osnovnikh napravleni razvitiya otrasli. : Obzornaya informatsiya/
   TSBNTI Minmontazhspetsstroya SSSR; vipusk 3)

4. KIM V.G., LUKJYANOV K.I., POLUYANOV E.P. Recomendatsii po viboru
   effectivnikh metodov montazha vityazhnikh trub /TSBNTI Minmontazh
   spetsstroya SSSR. - M., 1987. - 24 pg.