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Optimum Mechanization Schemes for the Thermopower Equipment Assembling at Electric Plants

The assembly process of electric plant thermopower equipment can be mechanized on the basis of several schemes.

Previous surveys of the Power Building and Assembly General Direction reached the conclusion that the mechanization of the thermomechanical equipment assembling is more rational from both technical and economical point of view, with the help of travelling cranes [1].

Yet, this mechanization scheme cannot be adopted on the assembly sites of electric plants, bearing in mind that the constructive solution in use at the boiler room does not permit the mounting of travelling cranes.

The half-open constructive system of the boiler room calls for the adoption of a scheme implying the use of tower or mobile cranes (on caterpillar or on tire). With this aim in view, mechanization schemes have been studied in a research work elaborated at the Power Building and Assembly General Direction, based on mobile cranes (on caterpillar or on tire) which proved their superiority from the point of view of the technical-economic indicators [1].

The use of mobile cranes is possible for a certain technology, based on pre-assembly in blocks of small sizes and weight (5—10 tf). The assembly in large blocks of the thermopower equipment, namely of the steam boilers, which determines finally the time required for the assembly of the whole thermopower plant, complies with the adoption of the mechanization scheme implying the use of tower cranes.

Hence, in the light of the technology adopted at pre-assembling, either the scheme of mechanization with mobile cranes (on caterpillar or on tire) or the mechanization scheme implying the use of tower cranes can be used on the assembly sites of thermopower plants.

We shall study below the influence of the pace of the continuous flow on the assembly of the thermopower equipment of the electric plant.

The increase of the continuous flow pace entails a raise in the overhead charges proportional to the time. At the same time, some costs related to the storage of materials and equipment, as well as some site operation expenses (accommodation areas, assembly platforms, tool deposits, etc.) are decreasing.

The mechanization costs vary also in accordance with the continuous flow pace. For instance, in a survey [2] it has been shown that at the assembly of a steam boiler with the help of one crane, the latter is used 5h.23′ a day, i.e. in proportion of 65 per cent.

Based on these conclusions, we present schematically in Fig. 1 the necessary number of cranes for the assembly of three steam boilers in continuous flow.

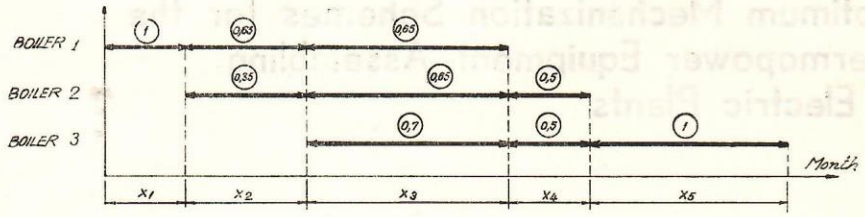

Fig. 1

The diverse time-limits for the assembly of boilers x_1, x_2, x_3, x_4 and x_5 in which:

x_1 is the time limit elapsed between the start of assembly work at boiler 1 and the start of assembly at boiler 2;

x_2 — idem, between boilers 2 and 3;

x_3 — the time-limit elapsed between the start of assembly work at boiler 3 and the completion of assembly at boiler 1;

x_4 — the time-limit elapsed between the completion of assembling at boiler 1 and the completion of assembly at boiler 2;

x_5 — idem, between boilers 2 and 3,

vary contingent upon the relation between the cranes needed and in existence, namely:

$$\frac{0.65}{1} \times x_1 + x_2 + x_3 = t$$

$$\frac{0.65}{0.35} \times x_2 + x_3 + \frac{0.65}{0.5}\, x_4 = t$$

$$\frac{0.65}{0.7} \times x_3 + \frac{0.65}{0.5}\, x_4 + \frac{0.65}{1}\, x_5 = t$$

for $t = 10, 11, 12, 13, 14$ months.

The criterion function to be minimized:

$$[MIN]Z = M(x_1 + x_2 + 2 \cdot x_3 + x_4 + x_5) +$$
$$+ R(x_1 + x_2 + x_3 + x_4 + x_5) + C(x_1 + x_2 + x_5) + 2 \cdot 5\, C \cdot x_3$$

in which:

x_1, x_2, x_3, x_4, and x_5 are the significances shown previously,

M is the hourly cost of mechanization (the hire of cranes),

R is the hourly value of the overhead charges quota, proportional to the duration of execution,

C is the value of expenses inversely proportional to the duration of execution.

The value of M is of 330 lei per hour for the tower cranes, and 250 lei per hour for the heavy cranes of tire (of the Coles type).

The value of R is of 1.430 lei per hour.

The value of C is formed of: 1) C_1 — the cost of materials and equipment storage, calculated in [3] and amounting to 458 lei per hour, and C_2 — site operation expenses (accommodation areas, assembly platforms, tool deposits, etc.) which represent:

$$C_2 = \frac{(0.5 \times 4.500.000) \text{ (value of site organization)}}{20 \text{ (months) } 200 \text{ (hours)}} = 542 \text{ lei per hour}$$

$$C = C_1 + C_2 = 458 + 542 = 1{,}000 \text{ lei per hour.}$$

By means of these data, all of them expressing monthly values, 200 hours, the criterion function to be minimized is written:

$$[MIN]Z = 200 \times 330\,(x_1 + x_2 + 2x_3 + x_4 + x_5) + 200 \times 1{,}430\,(x_1 + x_2 + x_3 + x_4 + x_5) + 200 \times 1{,}000\,(x_1 + x_4 + x_5) + 2.5 \times 200 \times 1{,}000\,x_3 = 66{,}000\,(x_1 + x_2 + 2x_3 + x_4 + x_5) + 286{,}000\,(x_1 + x_2 + x_3 + x_4 + x_5) + 200{,}000\,(x_1 + x_2 + x_4 + x_5 + 500{,}000\,x_3 = 552{,}000\,(x_1 + x_2 + 552{,}000\,(x_4 + x_5)$$

with the restrictive conditions:

$$0.65\,x_1 + x_2 + x_3 = t$$

$$\frac{0.65}{0.35}\,x_2 + x_3 + \frac{0.65}{0.50}\,x_4 = t$$

$$\frac{0.65}{0.70}\,x_3 + \frac{0.65}{0.50}\,x_4 + 0.65\,x_4 = t$$

and

in variant 1	*in variant* 2
$3 < x_1 < t$	$x_1 < t$
$3 < x_2 < t$	$x_2 < t$

for $t = 10, 11, 12, 13, 14$ months.

The solving of this problem of linear programming is conducive to the following results (see table 1).

In variant 1 (table 1) the values x_1 and x_2 for $t = 10, 11, 12, 13, 14$, which optimize function Z, are:

$x_1 = 3.956$ months

$x_2 = 3$ months

It has been noted that concomitantly with the increase of the time assigned for the assembly of a boiler (t), the value of function Z is also growing.

In the lower part of table 1 the real time-limits X_1, X_2, X_3, X_4, X_5 resulting from multiplying the x_1, x_2, x_3, x_4 and x_5 values, for each boiler,

TABLE 1

	t, months				
	10	11	12	13	14
X_1	3.956	3.956	3.956	3.956	3.956
X_2	3	3	3	3	3
X_3	4.428	5.428	6.428	7.428	8.428
X_4	0	0	0	0	0
X_5	9.058	9.167	9.227	9.387	9.387
	12,905,220	13,883,880	14,862,540	15,841,200	16,819,860

Boiler	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
X_1	2.572	—	—	2.572	—	—	2.572	—	—	2.572	—	—	2.572	—	—
X_2	3	5.572	—	3	5.572	—	3	5.572	—	3	5.572	—	3	5.572	—
X_3	4.428	4.428	4.2	5.428	5.428	5.1	6.428	6.428	6	7.428	7.428	6.9	8.428	8.428	7.9
X_4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
X_5	—	—	5.8	—	—	5.9	—	—	6	—	—	6.1	—	—	6.1
t	10	10	10	11	11	11	12	12	12	13	13	13	14	14	14

with the mechanization coefficients (restrictive conditions: $f(x_1) = t$), have been calculated.

The last row contains the verifications of the framing within the assembly time t.

In variant 2 (table 2) it has been noted that the optimum solution is achieved when starting the assembly concomitantly at the three boilers.

TABLE 2

	t, months				
	10	11	12	13	14
x_1	0	0	0	0	0
x_2	0	0	0	0	0
x_3	10	11	12	13	14
x_4	0	0	0	0	0
x_5	1.098	1.208	1.318	1.428	1.538
	9,786,593	10,765,250	11,743,910	12,722,570	13,701,260

In this variant, too, the value of function Z increases in step with the growth of the assembly time (t).

In conclusion:

— The function is optimized for a zero pace of assembly flow (concomitant assembly);

— Since, due to technical and organizational reasons the concomitant assembly cannot be achieved, table 1 shows the assembly time-limits (X_1, X_2, X_3, X_4 and X_5) for diverse values of the assembly duration.

For these values of the assembly time the overhead charges present a minimum Z.

— The value of the overhead expenses grows in step with the time assigned to the assembly of a boiler t. Considering the direct constant expenses (materials and amount of labour), it results that in step with the increase of the assembly time-limit, the value of investment is also growing.

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SCHEMAS OPTIMUMS DE MECANISATION POUR LE MONTAGE DE L'EQUIPEMENT THERMOENERGETIQUE DES CENTRALES ELECTRIQUES

La mécanisation du montage thermoénergétique peut être réalisée au moyen de plusieurs schémas. Les schémas de mécanisation tiennent également compte du rythme de montage. On étudie dans cet article les possibilités optimums conduisant à des schémas de mécanisation du montage, pour un minimum de dépenses.

La solution du problème mène à l'application de la programmation linéaire, et on atteint les résultats suivants :

— Le rythme devient optimum pour un pas nul ;

— on obtient les valeurs correspondant au pas optimum du rythme ;

— la valeur des dépenses générales augmente avec l'augmentation de la durée de montage d'une chaudière.

ОПТИМАЛЬНЫЕ СХЕМЫ МЕХАНИЗАЦИИ МОНТАЖА ТЕРМОЭНЕРГЕТИЧЕСКОГО ОБОРУДОВАНИЯ ЦЕНТРАЛЬНЫХ ЭЛЕКТРОСТАНЦИЙ

Механизация монтажа термоэнергетического оборудования может быть осуществлена по различным схемам. Схемы механизации учитывают и поточный шаг монтажа. Рассматривается оптимальный шаг, позволяющий разработать наиболее дешевые схемы механизации.

Решение этого вопроса ведет к применению линейного планирования, дающего следующие результаты:

— определяется оптимальный поток для нулевого шага;

— определяются показатели для оптимального поточного шага;

— общие расходы увеличиваются одновременно с ростом продолжительности монтажа котла.