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INFORMATION AND LOGICAL MODEL OF TRACING OF TECHNOLOGICAL PIPELINES

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Abstract: In the article the statement of the problem of choosing the optimal spatial arrangement of trails of the technological pipelines within the plant premises, taking into account existing standards and design rules is considered.

For problem formalization we will make following assumptions: trace is made up of the rectilinear fragments located to in parallel coordinate axes; initial and final points of lines are combined with the centers of devices; points of transition from a floor on a floor are combined with the centers of devices-sources of lines.

As a result of the decision of problems of a process equipments choice [1] and placing [2] the initial information for tracing of technological communications is received: N – quantity of devices; (x_i, y_i, z_i), i = 1, 2, ..., N – coordinates of the centers of devices; (a_i, b_i, c_i), i =1, 2, ..., N – overall dimensions of devices; (X_c, Y_c, Z_c) – overall dimensions of an industrial premises.

Let's designate floor number through ρ. Then for a lining of pipelines parallel to an axis OY level $\left[U^y_{\rho*}, U^{y*}_{\rho}\right]$, and for the pipelines parallel to an axis OX level $\left[U^x_{\rho*}, U^{x*}_{\rho}\right]$ is allocated. At each level of pipelines laid at no more than two rows.

Let's enter into consideration matrix F (3×L) for the characteristic of set of lines. Here L – quantity of communications; f_{1j} and f_{2j} – numbers of the devices connected by j-th line; $f_{3j} \in \{1, 2, ..., R\}$ – number of a connecting network to which possesses j-th line. We will characterize each line by a vector

$$T_j = \left(x_{j0}, y_{j0}, z_{j0}, x_{j1}, y_{j1}, z_{j1}, ..., x_{jk_j}, y_{jk_j}, z_{jk_j}\right),$$

where $j = 1, 2, ..., L$ – line number; (x_{j0}, y_{j0}, z_{j0}) – coordinates of the beginning of a line (i.e. coordinates of the center of the device f_{1j}); $\left(x_{jk_j}, y_{jk_j}, z_{jk_j}\right)$ – coordinates of the end of a line (i.e. coordinates of the center of the device f_{2j}); (x_{jn}, y_{jn}, z_{jn}),

$n \in \{1, 2, ..., k_j - 1\}$ – coordinates of points of an inflection of a line; k_j – quantity of rectilinear fragments. Let's consider conditions which should be executed at tracing of pipelines. We will designate through m-number of a condition and we will unite all lines for which the condition m in set M^m is satisfied.

Condition 1. Lines from set M^1 are laid within an industrial premise. Let d_j – diameter of the pipeline of *j*-th technological communications; l_j – a thickness of isolation of *j*-th pipeline.

Then for any $j \in M^i$ and any $n = 0, 1, 2, ..., k_j$ there is

$$\begin{cases} \dfrac{d_j}{2} + l_j + l_d \le x_{jn} \le X_c - l_j - l_d - \dfrac{d_j}{2}; \\ \dfrac{d_j}{2} + l_j + l_d \le y_{jn} \le Y_c - l_j - l_d - \dfrac{d_j}{2}; \\ \dfrac{d_j}{2} + l_l + l_d \le z_{jn} \le Z_c - l_j - l_d - \dfrac{d_j}{2}. \end{cases} \quad (1)$$

Condition 2. For any point of a inflection $(x_{jn}, y_{jn}, z_{jn}), n = 1, 2, ..., k_j - 1$ of *j*-th line $j \in M^2$, there is such number ρ that

$$z_{jn} \in \left[U_{\rho*}^{x}, U_{\rho}^{x*}\right] \cup \left[U_{\rho*}^{y}, U_{\rho}^{y*}\right]. \quad (2)$$

i.e. any point of an inflection of a line is in one of the levels allocated for a lining of lines.

Condition 3. We take some horizontal fragment $(x_{jn}, y_{jn}, z_{jn}; x_{jn+1}, y_{jn+1}, z_{jn+1})$ of a line $T_j \in M^3$. Then or $x_{jn+1} \ne x_{jn}$ (the fragment is parallel to an axis), or $y_{jn+1} \ne y_{jn}$ (the fragment is parallel to an axis)

$$z_{jn}, z_{jn+1} \in \left[U_{\rho*}^{x}, U_{\rho}^{x*}\right] \wedge z_{jn}, z_{jn+1} \in \left[U_{\rho*}^{y}, U_{\rho}^{y*}\right]. \quad (3)$$

This condition allows defining level of a fragment of a line depending on its direction.

Condition 4. In lines possibility of occurrence of stagnant zones is excluded from set M^4. We will divide set M^4 into two subsets: M_c^4 – pipelines on which liquids flow; M_g^4 – pipelines for gases. If $j \in M_c^4$ then the pipeline line shouldn't have local minima; if $j \in M_g^4$ then the pipeline line shouldn't have local maxima. Hence, for any $j \in M_c^4$ and any $n_1, n_2, n_3 \in \{0, 1, 2, ..., k_j\}$ such that $n_1 > n_2 > n_3$ that inequalities $z_{jn_1} - z_{jn_2} > 0, z_{jn_3} - z_{jn_2} > 0$ can't be carried out simultaneously.

This condition we will write down in the form of an inequality:

$$z_{jn1} - z_{jn2} > 0 \wedge z_{jn3} - z_{jn2} > 0, \forall j \in M^4,$$
$$\forall n_1, n_2, n_3 \in \{0, 1, 2, ..., k_j\}: n_1 > n_2 > n_3 . \quad (4)$$

Condition 5. A of condition not crossings of lines. Let $j', j'' \in M^5$. We take any points $c'(x_{c'}, y_{c'}, z_{c'}) \in T_{j'}, c''(x_{c''}, y_{c''}, z_{c''}) \in T_{j''}$. We will define distance as $\rho(c', c'') = \sqrt{(x_{c'} - x_{c''})^2 + (y_{c'} - y_{c''})^2 + (z_{c'} - z_{c''})^2}$, then the condition 5 can be written down in a kind

$$\rho(c', c'') \geq \frac{d_{j'} + d_{j''}}{2} + l_{j'} + l_{j''} + l_d, \forall j', j'' \in M^5. \quad (5)$$

The *condition 6* consists that lines from set M^6 aren't crossed with columns of a building construction. Let $j \in M^6$. We take any point $c'(x_{c'} y_{c'}, z_{c'}) \in T_j$. The condition 6 can be written down in a kind

$$\left(\left| \overline{x}^K - x_{c'} \right| \geq \frac{a_j + d_j}{2} + l_j + l_d \right) \vee \left(\left| \overline{x}^K - y_{c'} \right| \geq \frac{b_j + d_j}{2} + l_j + l_d \right). \quad (6)$$

Condition 7. A condition of not crossings of lines with the placed devices. Let $j \in M^7$. We take any point $c'(x_{c'}, y_{c'}, z_{c'}) \in T_j$. Let further $i \in \{1, 2, ..., N\}$ – any of numbers of the placed devices, excepting devices f_{1j} and f_{2j}, and S_i – width of a zone of service of this device. Then

$$\left(|x_i - x_{c'}| \geq \frac{\overline{a}_i + d_j}{2} + S_i + l_j + l_d \right) \vee \left(|y_i - y_{c'}| \geq \frac{b_i + d_j}{2} + S_i + l_j + l_d \right). \quad (7)$$

Condition 8. On conditions of production zones, forbidden for a lining of pipelines should be provided. Let's designate through $(x_m, y_m, z_m), m = 1, 2, ..., k_m$ – coordinates of the centers of such zones; $(\overline{a}_m, \overline{b}_m, \overline{z}_m)$ – their overall dimensions. Then for all $j \in H^8$ and any point $c'(x_{c'}, y_{c'}, x_{c'}) \in T_j$ it is had

$$\left(|\overline{x}_m - x_{c'}| \geq \frac{\overline{a}_m + d_j}{2} + l_j + l_d \right) \vee \left(|\overline{y}_m - y_{c'}| \geq \frac{\overline{b}_m + d_j}{2} + l_j + l_d \right)$$
$$\vee \left(|\overline{z}_m - z_{c'}| \geq \frac{\overline{c}_m + d_j}{2} + l_j + l_d \right). \quad (8)$$

Condition 9. This condition is shown by safety precautions to pipelines with explosive, combustible, inflammable and aggressive substances. Let M^9_{ds} (ds – dungarees substances)– set of pipelines on which explosive, combustible, inflammable substances are transported; M^9_{aa} (aa – aqua's aggressive)– set of pipelines on which acids and other aggressive substances are transported. Let's choose $M^9 = M^9_{\text{ds}} \cup M^9_{\text{aa}}$. The pipelines entering into set M^9 settle down as follows: if the distance between points $c' \in T_j \in M^9_{\text{ds}}, c'' \in T_j \in M^9_{\text{aa}}$ doesn't surpass the set size l_{ds}, then $z_{c'} \geq z_{c''}$. Thus for any points $c' \in T_j \in M^9_{\text{ds}}, c'' \in T_j \in M^9_{\text{aa}}$ it is had

$$\left(\left(\rho(c',c'')\le l_{\text{ds}}\right)\wedge\left(z_{c'}\ge z_{c''}\right)\right)\vee\left(\rho(c',c'')\ge l_{\text{ds}}\right). \quad (9)$$

Condition 10. The length of the pipelines united in set M^{10} shouldn't exceed in advance set sizes σ_j. Thus for any $j\in M^{10}$

$$\sum_{n=0}^{k_j}\left(\left|x_{jn+1}-x_{jn}\right|+\left|y_{jn+1}-y_{jn}\right|+\left|z_{\text{l}n+1}-z_{jn}\right|\right)\le\sigma_j\,. \quad (10)$$

As criterion of economic efficiency of the design decision we will consider cost of capital expenses for a lining of pipelines

$$I=\sum_{j=1}^{L}\left(S_{1j}\varphi_j+S_{2j}K_j\right), \quad (11)$$

where S_{1j} – cost of unit of length of *j*-th pipeline; $\varphi_j=\sum_{n=0}^{K_j-1}\left(\left|x_{jn+1}-x_{jn}\right|+\right.$ $\left.+\left|y_{jn+1}-y_{jn}\right|+\left|z_{jn+1}-z_{jn}\right|\right)$ – length of *j*-th pipeline; S_{2j} – expenses for technical realization of one turn of the pipeline of *j*-th line; K_j – quantity of turns in *j*-th line.

Thus the problem of trace of technological communications can be formulated as follows: to find $T_j=\left(x_{j0},y_{j0},z_{j0};x_{j1},y_{j1},z_{j1};\ldots;x_{jk_j},y_{jk_j},z_{jk_j}\right),\ j=1,2,\ldots,L$ so that conditions (1) – (10) have been satisfied and the criterion (11) reached a minimum.

The developed model is used by working out of information system of support of design decisions on configuration multiassortment manufactures [3].

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Информационно-логическая модель трассировки технологических трубопроводов

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Аннотация: Рассмотрена постановка задачи выбора оптимального пространственного расположения трасс технологических трубопроводов в пределах производственного помещения с учетом существующих норм и правил проектирования.

Informationslogisches Modell der Trassierung der technologischen Rohrleitungen

Zusammenfassung: Es ist die Aufgabestellung der Auswahl der optimalen Raumanordnung der Trassen der technologischen Rohrleitungen im Betriebsraum mit Rücksicht auf die existierenden Normen und Projektierunsregeln betrachtet.

Modèle logique informatique du tracé des pipe-lines technologiques

Résumé: Est examinée la mise du problème du choix de l'arrangement spacial optimal des lignes des pipe-lines technologiques dans les limites du local industriel compte tenu des normes existantes et des règles de la conception.

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