THE STRUCTURAL OPTIMIZING OF METALLURGICAL INSTALLATIONS AND MECHANISMS

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ABSTRACT

The structural optimizing of used mechanisms in the machines construction and metallurgy through the further liberty degrees creation is essential projection problem, as it enters the closing mechanisms case with sliding case for steel teeming ladles.

KEYWORDS: sliding gate nozzle, casting steel, spatial mechanism.

1. The mechanisms structure optimizing through the further liberty degrees creation

In the fashionable machines construction and metallurgy, a distinguished attention must attached realization to some installations and machines fiabile, because the excited stops failures and bugs sundries, as well as the interventions for repairs tend important production loss, to extra costs and the labour productivity reduction. Therefore, the mechanisms structure optimizing through the further liberty degrees creation (in meaning Reşetov) it is an essential projection problem, as it will reason in the closing mechanisms case with case for steel teeming ladles [1].

Use experience to those in working metallurgical behaviour, it manages to the solution necessity to the next problems:

- The mechanisms tun in thermic valir behaviour, introducing needed his realization with big games;
- The practice failure of a parallelism faultless of joints journals;
- The fitting mistakes of mechanism in the difficult conditions, making failures production possibility;
- The mechanism jams owing to deformability in time.

These problems can solve themselves through the further liberty degrees creation, replacing the cylindric joints from the points c and d (figure 1), such as it was realized mechanism structure in the first stage, with round joints. In this case, it appears and a further mobility (the turnover tiller 4 around own journal).

***Fig. 1**. Skeleton diagram of spatial mechanism.*

At the beginning it is presented, the mechanism configurations fixing in this considered situation like a spatial mechanism. Further, it entails kinematic and kinetostatic mechanism, considering same respect.

The further tiller mobility to treat as in (1), observing as in any other position of tiller 4, must tested, generally, the equation:

$$\overline{CD}\times\overline{F}_{54}+\overline{CS}_4\times\overline{F}_4+\overline{M}_4=\overline{0} \qquad (1)$$

which, projected on the $\overline{CD}$ direction, becomes:

$$\left(\overline{CS}_4\times\overline{F}_4+\overline{M}_4\right)\overline{CD}=\overline{0} \qquad (2)$$

in which:

$\mathbf{S_4}$ is the centre of tiller mass 4, non-collinear with the CD direction. In the physical collinearity case, S_4 is an arbitrarypoint in which decreases the forces torsor applied to the tiller 4.

$\overline{\mathbf{F}}_4, \overline{\mathbf{M}}_4$ - the torsor elements of the forces system (active and of inertia) applied to the tiller. In the effected computations considered only the own weight of tiller $\overline{G}_4$ and, therefore, the relation (1) becomes:

$$\left(\overline{CS}_4 \times \overline{G}_4\right) \cdot \overline{CD} = \overline{0} \quad (3)$$

The torsor inertia rates negligible related the active forces through relative creeping mouvements.

2. The spatial mechanism configuration fixing

The mechanism reports to a determinate system journals of co-ordinate Oxyz, as in figure 1 (axis Oy is vertical).

Structural, the mechanism is constituted from a plan linkage and a spatial linkage, the point position D being defined of the unit vector components $\overline{u}_5$.

Case guide journal runs through the point E, considered stiff with layer and has the evinced direction through unit vector $\overline{u}_5$.

The centre of tiller mass 4, S_4, has excentricity d toward journal $\overline{CD}$ of tiller (from the processing mistakes and the dilatation owing to thermic field). For the space arrangement of tiller 4 is necessary to knowledge the point position S_4. Therefore, the input dates for the positions fixing are the following::

ℓ_{AB}, ℓ_{CB}, ℓ_{CC}, ℓ_{BC}, $A(x_A, y_A, z_A)$, ℓ_{CD}, $E(x_E, y_E, z_E)$, $\overline{u}_5$, $d = \ell_{PS_4}$ (it con-sidered $\overline{PS}_4 \perp \overline{CD}$, P being the middle of segment $\overline{CD}$).

The B point coordinates results from the equations:

$$\begin{aligned}&(x_B - x_A)^2 + (y_B - y_A)^2 = L_{AB}^2\\&x_B^2 + y_B^2 = \ell_{OB}^2\\&z_A = 0; z_B = 0\end{aligned} \quad (4)$$

The C point coordinates calculates from the equations:

$$\begin{aligned}&(x_C - x_B)^2 + (y_C - y_B)^2 = \ell_{BC}^2\\&(x_C - x_O)^2 + (y_C - y_O)^2 = \ell_{OC}^2\\&z_C = 0\end{aligned} \quad (5)$$

The D point coordinates entails from the equation:

$$(x_C - x_D)^2 + (y_C - y_D)^2 + z_D^2 = \ell_{CD}^2 \quad (6)$$

whereupon it adds the relation:

$$\overline{ED} = \overline{u}_5 \cdot L_{ED} \quad (7)$$

which, written scalar, results:

$$\begin{aligned}&x_D - x_E = u_{5x} \cdot L_{ED}\\&y_D - y_E = u_{5y} \cdot L_{ED}\\&z_D - z_E = u_{5z} \cdot L_{ED}\end{aligned} \quad (7')$$

The P point coordinates results as subtotal to the co-ordinated points C şi D, so that:

$$x_P = \frac{x_C + x_D}{2}, \quad y_P = \frac{y_C + y_D}{2}, \quad z_P = \frac{z_C + z_D}{2} \quad (8)$$

The point position S_4 results from the equations:

$$\overline{CP} \cdot \overline{PS}_4 = 0 \quad (9)$$

$$\left|\overline{PS}_4\right| = d \quad (10)$$

whereupon it adds the relation (3).

In this case, the excentricity d appears effective through dilatation owing to thermic valid field and of processing, considering the execution necessity from more catches (also, you see the chamfering for key).

The relations (9) and (3), written scalar, become:

$$\begin{aligned}&(x_P - x_C)(x_{S_4} - x_P) +\\&+ (y_P - y_C)(y_{S_4} - y_P) +\\&+ z_P(z_{S_4} - z_P) = 0\end{aligned} \quad (9')$$

$$\begin{aligned}&(x_P - x_{S_4})^2 + (y_P - y_{S_4})^2 +\\&+ (z_P - z_{S_4})^2 = d^2\end{aligned} \quad (10')$$

$$z_D(x_{S_4} - x_C) = (x_D - x_C)z_{S_4} \quad (3')$$

(G_4 has component obly after journal y).

3. The fixing spatial mechanism kinematics

In accelerations and speeds computation were considered the kinematic detached parameters, relative speed v_{21} and relative acceleration a_{21}.

3.1 Speeds fixing

For the points B and C they act themselves in classic mode:

$B \in 3,2$

$\overline{v}_B = \overline{v}_{B1} + \overline{v}_{BB1}$, or

$$\overline{\omega}_3 \times \overline{OB} = \overline{\omega}_1 \times \overline{AB} + v_{21} \frac{\overline{AB}}{L_{AB}} \quad (11)$$

which, expressed numeric, put down themselves:

$$-y_B \cdot \omega_3 = (y_A - y_B)\omega_1 + \frac{v_{21}}{L_{AB}}(x_B - x_A)$$
$$x_B \cdot \omega_3 = (x_B - x_A)\omega_1 + \frac{v_{21}}{L_{AB}}(x_B - y_A) \quad (11')$$

whence it results ω_1 and ω_3.

$$\bar{v}_C = \omega_3 \times \overline{OC} \quad (12)$$

or written numeric

$$v_{Cx} = -y_C \cdot \omega_3$$
$$v_{Cy} = x_C \cdot \omega_3 \quad (12')$$

For fixing v_D and v_{CD}, put down themselves the equations:

$$\bar{v}_D \cdot \bar{u}_5 = \bar{\omega}_3 \times \overline{OC} + v_{DC} \quad (13)$$
$$\bar{v}_{DC} \cdot \overline{DC} = 0 \quad (14)$$

which, for numeric computation, put down themselves so:

$$v_D \cdot u_{5x} = -y_C \cdot \omega_3 + v_{DCx}$$
$$v_D \cdot u_{5y} = x_C \cdot \omega_3 + v_{DCy} \quad (13')$$
$$v_D \cdot u_{5z} = 0 + v_{DCz}$$

(in considered case $u_{5z} = 0$)

$$v_{DCx}(x_C - x_D) + v_{DCy}(x_C - x_D) - v_{DCz} \cdot z_D = 0 \quad (14')$$

For vector computation $\bar{\omega}_4$, puts down:

$$\bar{v}_{\underline{D}} = \bar{v}_{\underline{\underline{DC}}} + \bar{v}_{\underline{DC}}$$
$$\bar{v}_D = \bar{v}_C + \bar{\omega}_4 \times \overline{CD} \quad (15)$$

from which take either two written numeric equations so:

$$v_{Dx} = v_{Cx} + z_D \cdot \omega_{4y} - \omega_{4z}(y_D - y_C)$$
$$v_{Dy} = v_{Cy} + \omega_{4z}(x_D - x_C) - \omega_{4x} \cdot z_D \quad (15')$$

whereupon it combines differential equation (3)

$$\left[\bar{\omega}_4 \times \left(\overline{CD} \times \overline{CS}_4\right)\right] \cdot \bar{G}_4 = 0, \text{sau}$$
$$\left[\overline{CD} \cdot \left(\bar{\omega}_4 \cdot \overline{CS}_4\right) - \overline{CS}_4\left(\bar{\omega}_4 \cdot \overline{CD}\right)\right] \cdot \bar{G}_4 = 0 \quad (16)$$

which written numeric, becomes:

$$\left(\omega_{4x}CS_{4x} + \omega_{4y}CS_{4y} + \omega_{4z}CS_{4z}\right) \cdot \left(-CD_y G_4\right) - \left(\omega_{4x}CD_x + \omega_{4y}CD_y + \omega_{4z}CD_z\right) \cdot CS_{4y} \cdot G_4 = 0 \quad (16')$$

3.2 Accelerations fixing

For fixing ε_1 and ε_3 puts down the equation:

$$\bar{a}_B^n + \bar{a}_B^t = \bar{a}_{B_1}^n + \bar{a}_{B_1}^t + \bar{a}_{BB} + \bar{a}_{BB_1}^c \quad (17)$$

in which:

$$\bar{a}_B^n = -\omega_3^2 \|OB\|$$
$$\bar{a}_B^t = \bar{\varepsilon}_3 \times \overline{OB}$$
$$\bar{a}_{B_1}^n = -\omega_1^2 \cdot AB$$
$$\bar{a}_{B_1}^t = \bar{\varepsilon}_1 \times \left\|\overline{AB}\right\|$$
$$\bar{a}_{BB_1} = 0 \text{ (deoarece } v_{BB_1} = ct\text{)}$$
$$a_{BB_1}^c = 2 \cdot \omega_1 \times \bar{v}_{BB_1}$$

Numeric, the equation (17) it expresses so:

$$-\omega_3^2 \cdot x_B - \varepsilon_3 \cdot y_B = -\omega_1^2(x_B - x_A) - \varepsilon_1(y_B - y_A) - (y_B - y_A)\frac{2\omega_1 \cdot v_{21}}{L_{AB}}$$
$$-\omega_3^2 \cdot y_B - \varepsilon_3 \cdot x_B = -\omega_1^2(y_B - y_A) - \varepsilon_1(x_B - x_A) - (x_B - x_A)\frac{2\omega_1 \cdot v_{21}}{L_{AB}} \quad (17')$$

For the point acceleration computation C puts down the equation:

$$\bar{a}_C = \bar{a}_C^n + \bar{a}_C^t \text{, or} \quad (18)$$
$$a_{Cx} = -\omega_3^2 x_C - \varepsilon_3 \cdot y_C$$
$$a_{Cy} = -\omega_3^2 y_C - \varepsilon_3 \cdot x_C \quad (18')$$

For the angular acceleration computation ε_4 puts down the equations:

$$\bar{a}_D = \bar{a}_C + \bar{\varepsilon}_4 \times \overline{CD} + \bar{\omega}_4 \times \bar{v}_{DC} \quad (19)$$

or

$$a_{Dx} = a_{Cx} + z_D \cdot \varepsilon_{4y} - \varepsilon_{4z}(y_D - y_C) + \omega_{4y} \cdot v_{DCz} - \omega_{4z} \cdot v_{DCy}$$

$$a_{Dy} = a_{Cy} + \varepsilon_{4z}(x_D - x_C) - \varepsilon_{4x} \cdot z_D + \omega_{4z} \cdot v_{DCx} - \omega_{4x} \cdot v_{DCz} \quad (19')$$

$$a_{Dz} = a_{Cz} + \varepsilon_{4x} \cdot z_D - \varepsilon_{4z}(x_D - x_C) + \omega_{4x} \cdot v_{DCy} - \omega_{4z} \cdot v_{DCx}$$

whereupon it adds the relations:

$$a_{Dx} = a_D \cdot u_{5x}$$
$$a_{Dy} = a_D \cdot u_{5y} \quad (19'')$$
$$a_{Dz} = a_D \cdot u_{5z}$$

and the auxiliary equation obtained through the relation derivation (16) related time:

$$\left\{\overline{\varepsilon}_4 \times \left(\overline{CD} \times \overline{CS}_4\right) + \overline{\omega}_4 \times \left[\overline{\omega}_4 \times \left(\overline{CD} \times \overline{CS}_4\right)\right]\right\} \cdot \overline{G}_4 = 0$$

or (20)

$$\left\{\overline{CD}\left(\overline{\varepsilon}_4 \cdot \overline{CS}_4\right) - \overline{CS}_4\left(\overline{\varepsilon}_4 \cdot \overline{CD}\right) + \overline{\omega}_4 \times \left[\overline{CD}\left(\overline{\omega}_4 \cdot \overline{CS}_4\right) - \overline{CS}_4\left(\overline{\omega}_4 \cdot \overline{CD}\right)\right]\right\} \cdot \overline{G}_4 = 0$$

For the numeric computation utilizes the relation:

$$-(y_D - y_C)\left[\varepsilon_{4x}(x_{S_4} - x_C) + \varepsilon_{4y}(y_{S_4} - y_C) + \varepsilon_{4z} \cdot z_{S_4}\right] + (y_{S_4} - y_C)\left[\varepsilon_{4x}(x_D - x_C) + \varepsilon_{4y}(y_D - y_C) + \varepsilon_{4z} \cdot z_D\right] - E_y = 0 \quad (20')$$

in which E_y is the projection on journal y of equation:

$$E = \overline{\omega}_4 \times \left[\overline{CD}\left(\overline{\omega}_4 \cdot \overline{CS}_4\right) - \overline{CS}_4\left(\overline{\omega}_4 \cdot \overline{CD}\right)\right]$$

(Maybe I was acting also, via the acceleration projection theorem practice, making $\overline{a}_D$ besides the computation deploys as it showed).

4. The fixing back strokes

4.1 Poise kinetostatic equations [2]

Pursuant to the journal system of co-ordinate Oxyz, the poise kinetostatic equations are:

3 scalar equations:

$$\overline{F}_{01} + \overline{F}_{21} + \overline{F}_m + \overline{F}_1 = \overline{0} \quad (21)$$

$$\overline{AB} \times \overline{F}_{21} + \overline{M}_{21} + \overline{AS}_1 \times \overline{F}_1 + \overline{M}_1 = \overline{0} \quad (22)$$

4 scalar equations:

$$-\overline{F}_{21} - \overline{F}_m + \overline{F}_{32} + \overline{F}_2 = \overline{0} \quad (23)$$

$$-\overline{M}_{21} + \overline{BS}_2 \times \overline{F}_2 + \overline{M}_2 = \overline{0} \quad (24)$$

$$\overline{F}_{21} \cdot \overline{AB} = 0 \quad (25)$$

6 scalar equation:

$$-\overline{OB} \times \overline{F}_{32} + \overline{OC} \times \overline{F}_{43} + \overline{M}_{03} + \overline{OS}_3 \times \overline{F}_3 + \overline{M}_3 = \overline{0} \quad (26)$$

$$-\overline{F}_{32} + \overline{F}_{43} + \overline{F}_{03} + \overline{F}_3 = \overline{0} \quad (27)$$

5 scalar equations:

$$-\overline{F}_{43} + \overline{F}_{54} + \overline{F}_4 = 0 \quad (28)$$

$$\overline{CD} \times \overline{F}_{54} + \overline{CS}_4 \times \overline{F}_4 + \overline{M}_4 = 0 \quad (29)$$

7 scalar equations:

$$\overline{F}_{05} - \overline{F}_{54} + \overline{F}_4 + \overline{M}_4 = 0 \quad (30)$$

$$\overline{M}_{05} + \overline{DS}_5 \times \overline{F}_4 + \overline{M}_5 = 0 \quad (31)$$

$$\overline{F}_{05} \cdot \overline{u}_5 = 0 \quad (32)$$

in which:

S_i (i = 1÷5) represents the centre of mass of elements 1÷5.

$\overline{F}_k, \overline{M}_k$ (k = 1÷5) represents the torsor of active and inertia forces, whence it acts over element k calculated in c.d.g.

In the described equations considered negligible scrubs.

The kinetostatic computation for the element 1 and 2 can do considering it the coplanar forces systems and, therefore, putting down for each element in part, only three poise scalar equations.

The back strokes from joint of A, slyder and the joint from B will appear therefore in computation only with two unknown scalar.

Essential, is of observed as the equation (29) is equivalent with only two scalar equations and not with three, as in the general case. This situation explains in that the fact as can entail a direction thereto it is verified equal.

Indeed, it can put down:

$$\left(\overline{CS}_4 \times \overline{F}_4 + \overline{M}_4\right) \cdot \overline{CD} = \overline{0} \quad (33)$$

This equation constitutes the ground rule of method for the kinematic computation, as it saw.

4.2 Fixing static back strokes

In a first approach can entail the back strokes without to take inaction, with so more with how the real movements of mechanism are dull. In this case, $\overline{F}_k, \overline{M}_k$ (k = 1÷5) represents the torsor of active forces (engines force, useful resistance force; it disregards the own weights).

Unknown problem are:

$$F_m, x_{01}, y_{01}, x_{21}, y_{21}, M_{21}, y_{32}, x_{32}, x_{03},$$
$$y_{03}, z_{03}, M_{x_{03}}, M_{y_{03}}, x_{43}, y_{43}, x_{54}, y_{54},$$
$$z_{54}, x_{05}, y_{05}, z_{05}, M_{x_{05}}, M_{y_{05}}, M_{z_{05}}$$

The ones 25 of unknown entail themselves through the system solution of 25 of derived poise equations from the relations (21) ÷ (32).

Considering as the mechanism is made aut from a plan kinematic chain and a spatial kinematic chain, further, enters a particular solution.

It solves the elements 1, 2, 3 in the plan xOy.

From the element poise 1, it was figuring 2

***Fig. 2**. The element poise 1.*

$$-\overline{F}_m + \overline{F}_{01} = \overline{0} \qquad (34)$$

From the moments equation toward the point of A

$$\overline{F}_{21} = \overline{0} \qquad (35)$$

From the element poise 2, it was figuring 3

***Fig. 3**. The element poise 2.*

M_{12} (back stroke) = 0, as it sees from the moments equation, where $B \equiv B'$.

$$\overline{F}_m + \overline{F}_{32} = \overline{0}$$
$$\overline{F}_{32} = -\overline{F}_m \qquad (36)$$

The element poise 3

$$\overline{F}_m + \overline{F}_{03} + \overline{F}'_{45} = 0 \qquad (37)$$

$$\overline{OB} \times \overline{F}_m + \overline{OC} \times \overline{F}'_{43} = 0 \qquad (38)$$

where it noted with $\overline{F}'_{43}$ the force projection $\overline{F}_{43}$ in the plan xOy.

For the numeric computation equations (37), (38) put down themselves respectively

$$F_m \frac{\|AB\|}{L_{AB}} + \|F_{01}\| + \|F'_{43}\| = \|0\| \qquad (37')$$

$$\frac{F_m}{L_{AB}} \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ x_B & y_B & 0 \\ x_B - x_A & y_B - y_A & 0 \end{vmatrix} + \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ x_C & y_C & 0 \\ F'_{43x} & F'_{43y} & 0 \end{vmatrix} = 0 \qquad (38')$$

From the element poise 4 can put down:

$$\overline{F}_{54} + \overline{F}_{34} = 0 \qquad (39)$$

$$\overline{F}_{43} = -\overline{F}_{34}\,;\ \overline{F}_{54} = -\overline{F}_{45} \qquad (40)$$

It takes from $\overline{F}_{45}$ only F_{45x} and F_{45y}.

$F_{45x} = 0$, being undertaken structure even joints.

Therefore,

$$F'_{45} = \begin{Vmatrix} F'_{45x} \\ F'_{45y} \\ 0 \end{Vmatrix} \qquad (41)$$

The element 5 solves independent, putting down the equations

$$\overline{F}_{45} + \overline{F}_{05} + \overline{F}_u = 0 \qquad (42)$$

$$\overline{F}_{05} \cdot \overline{u}_5 = 0 \qquad (43)$$

$$\overline{DE} \times \overline{F}_{05} + \overline{M}_{05} = 0 \qquad (44)$$

For the numeric computation equations (42), (43), (44) put down themselves respectively:

$$F_{45} \frac{\|CD\|}{L_{CD}} + \|F_{05}\| + F_u \|u_5\| = 0 \qquad (42')$$

$$F_{05x} \cdot u_{5x} + F_{05y} \cdot u_{5y} + F_{05z} \cdot u_{5z} = 0 \qquad (43')$$

$$\begin{Vmatrix} \bar{i} & \bar{j} & \bar{k} \\ x_E - x_D & y_E - y_D & z_E - z_D \\ F_{05x} & F_{05y} & F_{05z} \end{Vmatrix} + \begin{Vmatrix} M_{05x} \\ M_{05y} \\ M_{05z} \end{Vmatrix} = \begin{Vmatrix} 0 \\ 0 \\ 0 \end{Vmatrix} \qquad (44')$$

From the equations (42’), (43’), (44’), it results F_{45}, $\overline{F}_{05}$ and $\overline{M}_{05}$. The system (34) ÷ (40) also entails the others back strokes.

4.3 Fixing dynamic back strokes

Taking into account the inaction forces system, then in the equation (29), $\overline{F}4$ and $\overline{M}4$ become:

$$\overline{F}_4 = \overline{G}_4 + \overline{F}_{i4} \quad (45)$$

$$\overline{M}_4 = \overline{M}_{i4} \quad (46)$$

For the torsor computation of inaction forces of element 4 rates a journal system of co-ordinate joint with this:

$$\bar{i}' = \frac{\overline{CD}}{l_{CD}}\ ;\ \bar{j}' = \frac{\overline{PS_4}}{d}\ ;\ \overline{k'} = \bar{i}' \times \bar{j}' \quad (47)$$

It obtains

$$\overline{F}_{i4} = -m_4 \cdot \overline{a}_{S_4} \quad (48)$$

And

$$\overline{M}'_{i4} = \begin{Vmatrix} M_{i4x'} \\ M_{i4y'} \\ M_{i4z'} \end{Vmatrix} = -\begin{Vmatrix} \varepsilon_{4x'} \cdot J'_{11} + \omega_{4y'} \cdot \omega_{4z'}\left(J'_{33} - J'_{22}\right) \\ \varepsilon_{4y'} \cdot J'_{22} + \omega_{4x'} \cdot \omega_{4z'}\left(J'_{11} - J'_{33}\right) \\ \varepsilon_{4z'} \cdot J'_{33} + \omega_{4x'} \cdot \omega_{4y'}\left(J'_{22} - J'_{11}\right) \end{Vmatrix} \quad (49)$$

In relations (49), the resultant moment of inaction forces $\overline{M}i4$, it is expressed through its projections in the movable journals system (47), joint with the element 4.

The main inaction moments J'_{11}, J'_{22}, J'_{33} are constants.

But, to manage the computations, is needed angular speed utterance ω_4 and angular acceleration ε_4 through their projections on movable system journals (47). This it obtains through the transformations:

$$\left\|\omega'_4\right\| = \left\|A^{-1}\right\| \cdot \left\|\omega_4\right\| \quad (50)$$

$$\left\|\varepsilon'_4\right\| = \left\|A^{-1}\right\| \cdot \left\|\varepsilon_4\right\| \quad (51)$$

in which

$$\left\|A\right\| = \begin{Vmatrix} \bar{i} \cdot \bar{i}' & \bar{i} \cdot \bar{j}' & \bar{i} \cdot \overline{k'} \\ \bar{j} \cdot \bar{i}' & \bar{j} \cdot \bar{j}' & \bar{j} \cdot \overline{k'} \\ \overline{k} \cdot \bar{i}' & \overline{k} \cdot \bar{j}' & \overline{k} \cdot \overline{k'} \end{Vmatrix} \quad (52)$$

where: $\bar{i}, \bar{j}, \bar{k}$ are the unit vectors determinate journals system.

To obtain the resultant moment projections $\overline{M}i4$ on the determinate journals, it used the transformation:

$$\left\|M\right\|_{i4} = \left\|A\right\| \cdot \left\|M'_{i4}\right\| \quad (53)$$

where $\overline{M}'i4$ it calculates from the relations (49).

5. The rated programme and test data

The computations were done on a Pentium V computer, pursuant to logical draft from figure 4. The positions were entailed through method Newton-Raphson. The equations systems of speeds, accelerations and back strokes entail themselves by the agency of algorithm Gauss.

For the accurate values fixing of resultant vector $\overline{M}i4$ developed a iterative process, in which, initial, does not take into consideration, the element inaction 4 $\left(\overline{F}_4 = \overline{G}4\right)$.

In next iteration it acquaints the equation (45) the torsor of inaction forces of element 4, calculated with the determinate acceleration in previous iteration.

The computation ends when difference among concerted point S_4, determinate in two iteration series, corresponds rated imposed accuracy.

In the rated programme, the relative accuracy was imposed $\varepsilon = 10^{-4}$, being necessary 2-4 iterations for each position. The initial solution was found from chart.

So can entail the dynamic back strokes.

Further, it enters the rated ISTROM programme, for speeds positions fixing, accelerations and of mechanism back strokes in spatial variant, trap function hydraulic piston for a data input set.

In figure 5 enters trap function case speed variation piston for values sundries of managers cosines, while in figure 6 enters case acceleration variation, trap function piston for same values of versor $\overline{u}_5$.

For his values $\overline{u}_5$ ($u_{5x} = 1$; $u_{5y} = 0$; $u_{5z} = 0$), the correct assembly case, it distinguishes linearity of case speed curve, comparable with variant was planning of mechanism with case. The case acceleration for same managers cosines gives a maximum in the middle region of piston position, the minimum value filing to fine trap, with positive bearings over mechanism functionality.

Difference of about 2 m/s^2 among maximum and the minimum acceleration in curve zone, where it takes place the steel debit settlement indicates the possibility to an automation of casting with a high accuracy degree.

Analysing it was influencing the fitting mistakes or moves oxing to intensive field temperature, observes as running uniformity mechanism to be greatly determined of these variances.

So comparing curve 1 with 4 from figure 6, observes as in the curve situation 4 accelerations advance in continuous mode, which influences the negative automation installation stability.

6. Conclusions

It distinguishes generality, accuracy and perfect adaptability of mathematical described pattern in racing solution of any concrete appeared problems in exploitation, introducing possible automatic analysis of all fitting cases in any casting container type, the constructive input parameters function.

It obtain data tables and use charts, which give a very distinct image over mechanism parameters variation effect and over physical direction much more complete and more accurate meaning than whoever can be obtained from graphic method.

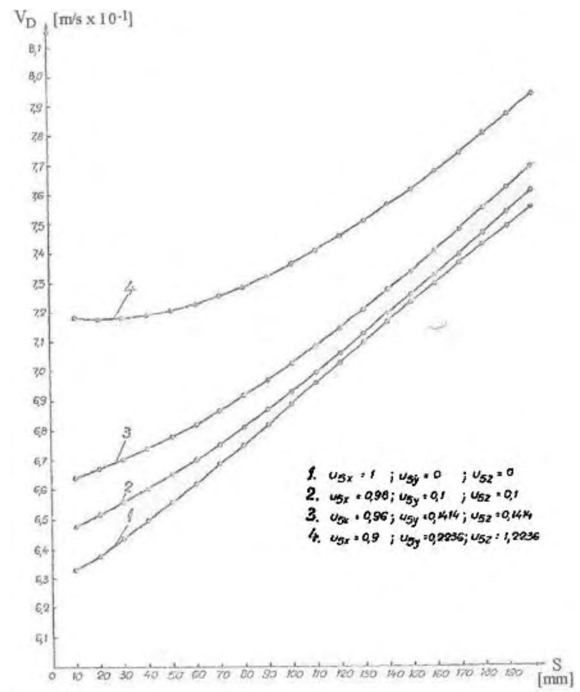

***Figure 5**. The speed variation V_D position dependency by hydraulic piston movement.*

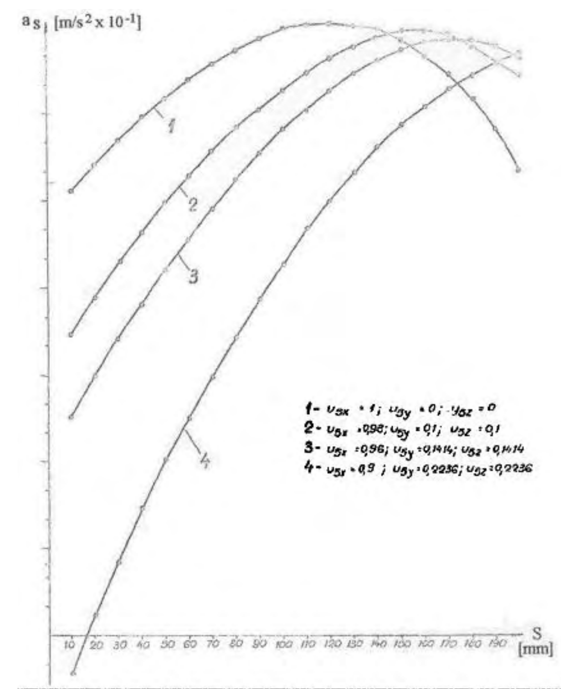

***Figure 6**. The acceleration variation a_S position dependency by hydraulic piston movement.*

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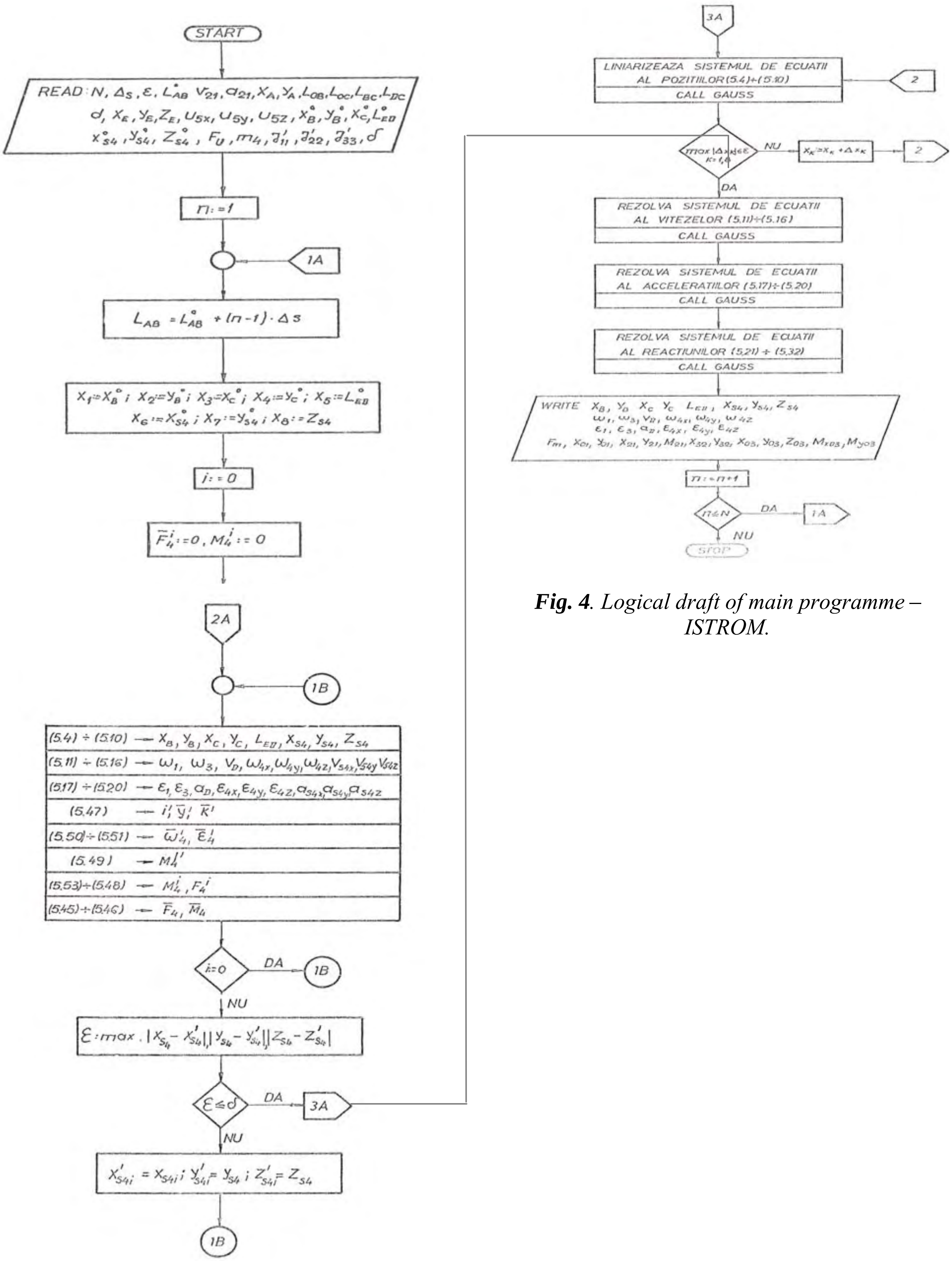

Fig. 4. Logical draft of main programme – ISTROM.