ANALYTICAL METHODS OF DESIGN OF HANDLING LIFTING DEVICES OF TRANSPORT VEHICLES

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The topicality of the problem

High-performance machines, automatic machines, industrial robots and manipulators are in demand for upgrading and expansion of technological capabilities of equipment. The spatial arrangements of machines execute more precise movements and provide different modes of performing required spatial movements of several output objects [1]. The use of manipulative devices created on the basis of spatial linkage closed variable loops, may extend through the creation of effective methods of their design.

Formulation of the task

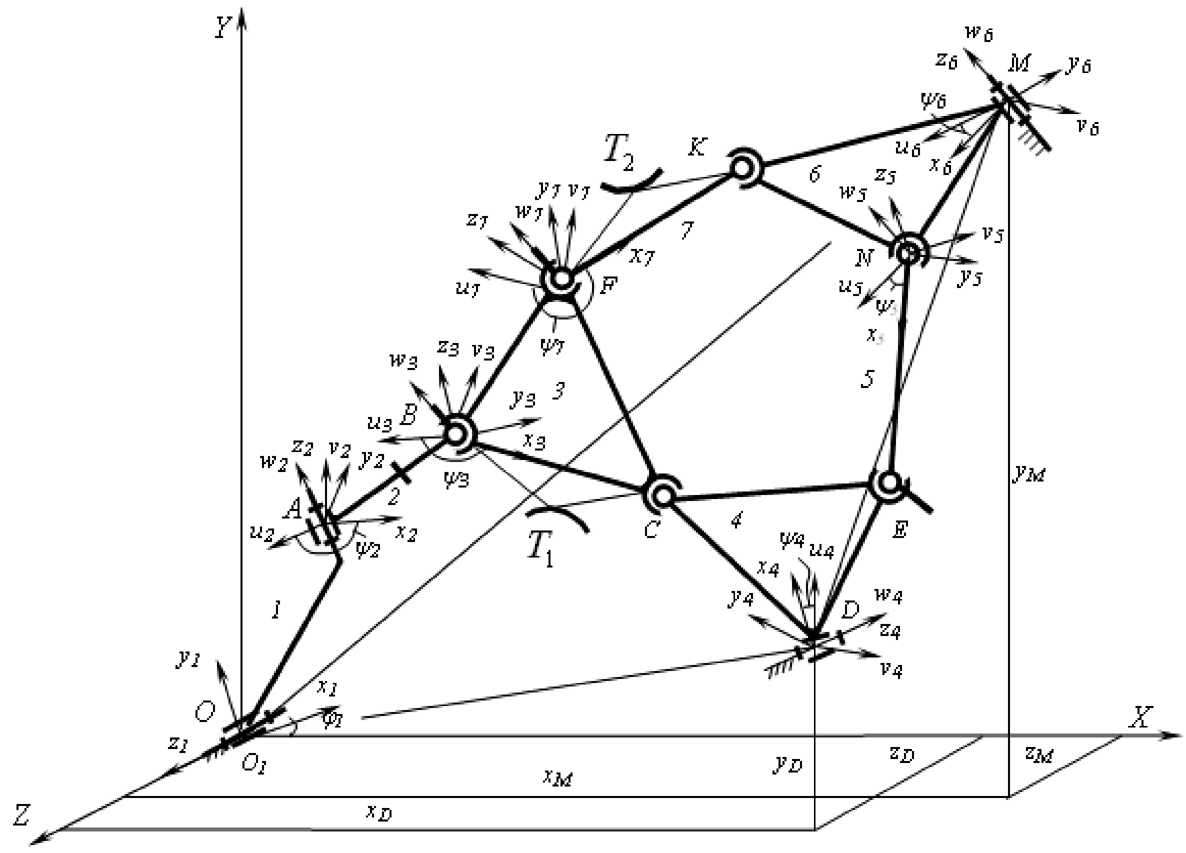
Spatial hinged-lever mechanism with the hydraulic cylinders allow to adjust the variable gear ratio of manipulation system, which can be effectively used in construction and road machines, transport devices for the transport system [2]. It is known that the change gear ratio in the motion handling system causes an additional change in the load on the engine, even if the actual object has a constant weight, and loaded with constant force. Consequently, the load changes significantly depend on the structural scheme and the geometric parameters of the mechanism of manipulation system, selected from the set of options (simultaneously with the choice of engine parameters and handling device).

This work is devoted to the kinematic synthesis of geometric parameters of concrete block diagrams of the many options manipulator device created on the basis of the spatial hinge-lever handled mechanism with variable gear ratio [3].

Let us consider the synthesis of spatial hinge-lever mechanism adjustable general form shown in the figure, given the provisions of the input level 4 and output points T_1, T_2, links 3, 7. To solve the problem of synthesis of the kinematic chain *OABCD* mechanism expressions of weighted difference are used

$$\Delta l_4 = l_4^2 - l_{4\phi}^2, \tag{1}$$

$$\Delta p_i = aX_{Ci} + bY_{Ci} + cZ_{Ci} - 1, \tag{2}$$



An expression of weighted difference (1) becomes A

$$\begin{gathered}\Delta l_i = X_{D1}^2 + Y_{D1}^2 + Z_{D1}^2 + x_{3C}^2 + z_{3C}^2 + y_{3C}^2 + X_{Ci}^{'2} + Y_{Ci}^{'2} + Z_{Ci}^{'2} - \\ - 2X_{D_1}\left[x_{3C}\cos(\varphi_1 + (\psi_2 + \psi_3)) + Z_{3C}\sin(\varphi_1 + (\psi_2 + \psi_3)) + X_C^{'}\right] - \\ - 2Y_{D_1}\left[x_{3C}\sin(\varphi_1 + (\psi_2 + \psi_3)) - Z_{3C}\cos(\varphi_1 + (\psi_2 + \psi_3)) + Y_C^{'}\right] - \\ - 2Z_{D_1}\left[y_{3C}\cos\alpha_{2,1} + Z_C^{'}\right] + \\ + 2x_{3C}\left[X_C^{'}\cos(\varphi_1 + (\psi_2 + \psi_3)) + Y_C^{'}\sin(\varphi_1 + (\psi_2 + \psi_3))\right] + \\ + 2y_{3C}\left[Z_C^{'}\cos\alpha_{2,1}\right] + 2z_{3C}\left[X_C^{'}\sin(\varphi_1 + (\psi_2 + \psi_3)) - Y_C^{'}\cos(\varphi_1 + (\psi_2 + \psi_3))\right] - l_{DC}^2 . \quad (3)\end{gathered}$$

Doing the expressions (1), (2) are defined by 8 parameters of *OABCD* chain: $X_{D_1},\ Y_{D_1},\ Z_{D_1},\ l_{D_1},\ a_{T_1},\ b_{T_1},\ c_{T_1},\ y_{3C}$.

Let us consider the task of synthesis-level of KM kinematic chain of $OABFKM$ mechanism.

$$\Delta l_i = l_{KM}^2 - l_{KM\phi}^2, \tag{4}$$

$$\Delta p_i = aX_{Ki} + bY_{Ki} + cZ_{Ki} - 1, \tag{5}$$

An expression of weighted difference (4) takes the form

$$
\begin{aligned}
\Delta l = & X_{M1}^2 + Y_{M1}^2 + Z_{M1}^2 + X_K^{'2} + Y_K^{'2} + Z_K^{'2} + x_{7K}^2 + y_{7K}^2 + z_{7K}^2 + \\
& + 2x_{7K} y_{7K} \cos\psi_7 \cos\mu \sin\mu + 2x_{7K} z_{7K} \cos\psi_7 \sin\psi_7 [(\cos^2\mu - \sin^2\mu) + 1] + \\
& + 2x_{7K}[(X_K^{'} - X_{M1})\cos\psi_7 \cos\mu + (Y_K^{'} + Y_{M1})\cos\psi_7 \sin\mu + (Z_K^{'} + Z_{M1})\sin\psi_7] + \\
& + 2z_{7K}[(X_K^{'} - X_{M1})\sin\psi_7 \cos\mu - (Y_K^{'} + Y_{M1})\sin\psi_7 \sin\mu + (Z_K^{'} - Z_{M1})\cos\psi_7] + \\
& + 2y_{7K}(X_K^{'} \sin\mu + Y_K^{'} \cos\mu) - 2y_{7K} \sin\mu X_{M1} - 2y_{7K} \cos\mu Y_{M1} - \\
& - 2(X_K^{'} X_{M1} + Y_K^{'} Y_{M1} + Z_K^{'} Z_{M1}) - l_{KM}^2 .
\end{aligned} \tag{6}
$$

We determine the geometrical parameters by the formulas:

$$
X_{M_1} = p_1, \quad Y_{M_1} = p_2, \quad Z_{M_1} = p_3, \quad l_{KM_1} = \sqrt{p_1^2 + p_2^2 + p_3^2 - p_4} \ .
$$

Synthesis of twenty geometrical parameters.

Expressions (5) have the form

$$
\begin{aligned}
& y^2 A_1 + y^2 x B_1 + y^2 z C_1 + y\left(x^2 D_1 + z^2 E_1 + xzF_1 + xG_1 + zH_1 + K_1\right) + \\
& + \left(x^3 L_1 + z^3 M_1 + x^2 z N_1 + xz^2 P_1 + x^2 d_1 + z^2 e_1 + xzf_1 + xg_1 + zh_1 + k_1\right) = 0,
\end{aligned} \tag{7}
$$

Doing the expressions (4,5) are defined by the formulas of 20 parameters:

$$
X_{D_1},\ Y_{D_1},\ Z_{D_1},\ l_{D_1},\ a_{T_1},\ b_{T_1},\ c_{T_1},\ y_{3C},\ x_{3F},\ y_{3F},\ z_{3F},\ l_{FT_2},
$$

$$
X_{M_1},\ Y_{M_1},\ Z_{M_1},\ l_{M_1},\ a_{T_2},\ b_{T_2},\ c_{T_2},\ y_{7K}.
$$

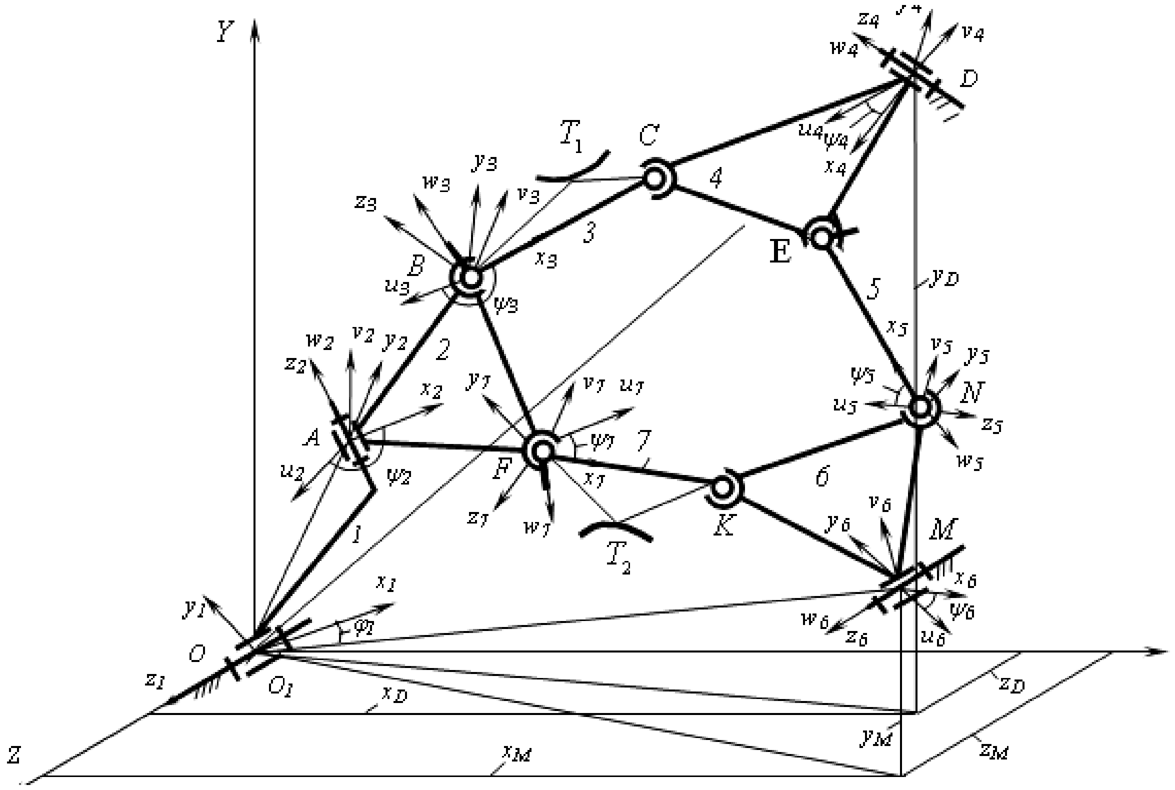
Synthesis of twenty-four and 30 geometric parameters of the mechanism, taking into account the calculated 6 parameters of the kinematic chain $DENM$, are determined by joint decision of the expression (6) and (7).

$$
X_{D_1},\ Y_{D_1},\ Z_{D_1},\ l_{D_1},\ a_{T_1},\ b_{T_1},\ c_{T_1},\ y_{3C},\ x_{3F},\ y_{3F},\ z_{3F},\ l_{FT_2},
$$

$$
X_{M_1},\ Y_{M_1},\ Z_{M_1},\ l_{M_1},\ a_{T_2},\ b_{T_{12}},\ c_{T_2},\ y_{7K},\ x_{6N},\ y_{6N},\ z_{6N},\ l_{EN},
$$

$$
\psi_2,\ \psi_3,\ \psi_4,\ \psi_5,\ \psi_6,\ \psi_7.
$$

Similarly, we solve the problem of synthesis of 30 parameters of the spatial manipulator lifting device in accordance with the drawing.



Conclusions

To solve the problem of synthesis of the kinematic chain *OABCD* mechanism expressions of weighted differences are used and eight geometrical parameters are denoted. Achieving the task of synthesis of kinematic chain *OABFKM* of mechanism 24 geometric parameters are defined. Solving the cinematic chain *DENM* allow us to define 30 geometric parameters of the spatial manipulator lifting device.

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