ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 1993

Seria: MECHANIKA z. 113 Nr kol. 1198

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CONTRIBUTION TO THE COMPUTER ANALYSIS OF THE HIGHER KINEMATIC PAIR

Summary. The system of programs presented enables to perform the analysis of the higher kinematic pair on the whole interval of motion. Input parameters can be obtained by both the mathematic description or the measurement of surfaces.

К РАСЧЕТУ ВЫСШЕЙ КИНЕМАТИЧЕСКОЙ ПАРЫ С ПОМОЩЮ ЭВМ

Резюме. Предлагаемый набор программ позволяет выполнить анализ высшей кинематической пары на целом интервале движения. Информацию о поверхностях необходимую для анализа точно получить на основе математического описания или измерения поверхностей.

ARTYKUŁ NA TEMAT ANALIZY KOMPUTEROWEJ WYŻSZYCH PAR KINEMATYCZNYCH

Streszczenie. Przedstawiony układ programów pozwala na dokonanie analizy pary kinematycznej wyższego rzędu w całym przedziale ruchu. Parametry wejściowe można uzyskać zarówno za pomocą opisu matematycznego, jak i pomiaru powierzchni.

1. INTRODUCTION

Analysis or synthesis of the higher kinematic pair, which is a port of three members mechanisms is in present works ussually performed in the mesch point, i. e. in the chosen time point and from the results obtained the mesch properties in the whole time interval are derived. This method the local approach enables to simplify relativelly the solution of the analysis of the mesch properties. The disadvantages of this method are the restriction of information of mesch properties to one point only and the necessity to express all quantities in the space which is connected with the pitch point. The purpose of the presented computer analysis is to remove the disadvantages by the file of programs in a user frindly form. The propposed file of programs enable the user to perform the local analysis in any contact point of two surfaces. The input parameters can be obtained by both the computation or the measurent.

2. SOLUTION

The file of program blocks is presented in fig 1. The whole file of programs is controlled by the main program, which enables the communication withthe user and the running of the whole file. The main program enables the, user to run the program file in a simple form without the necessity

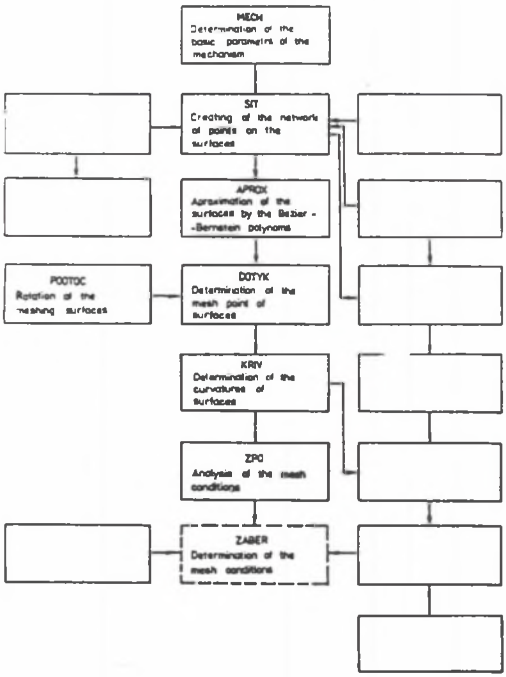

Fig. 1. The structure of the system
Rys. 1. Struktura systemu

to comprehend the problems of the calculations demanded. The fuunctions of the individual program blocks are following:

In the program block MECH the three members mechanism which contents the higher kinematic pair is determined. The basic data (see fig. 2) as the number of teeth z_2, z_3, module m, axis distance a, angle of axis $\sum$, translation of axis ΔV, ΔH, ΔJ are introduced.

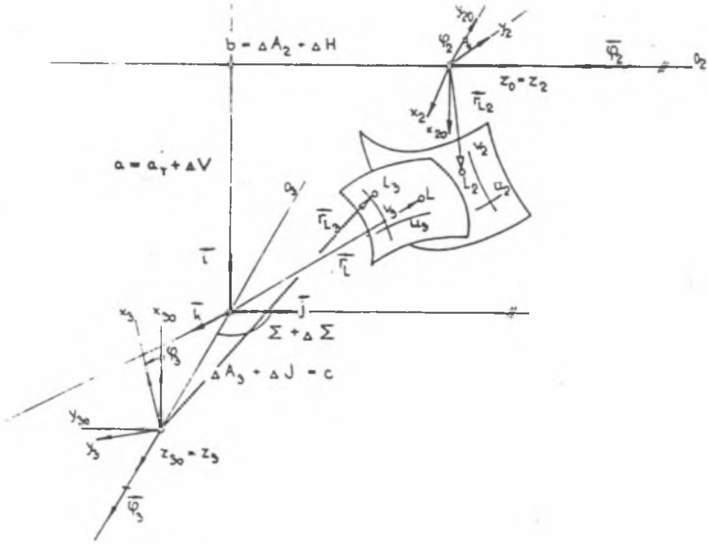

Fig. 2. The meshing surface and the used spaces
Rys. 2. Powierzchnie zazębienia i stosowane odstępy

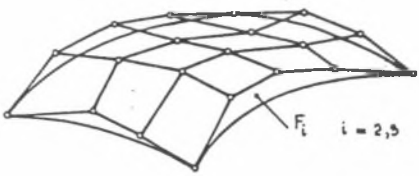

Fig. 3. The aproximation of the surface by the Bazier-Bernstein polynom
Rys. 3. Aproksymacja powierzchni za pomocą wielomianu Bazier-Bernsteina

In the program block SIT the coordinates of the network points on the meshing surfaces are determined. The calculation of network is performed on the basis of knowledge of the surface geometry, or from the values obtained by the surface measurement, or from the adjustment values of the produce maschine. In the case of the gears, the network of points is determinated separatelly for the tooth side surface and for the rooth of tooth surface. The transition from one etwork to another is continuous.

In the program block APROX the aproximation of the meshing surfaces is performed to using the known point network. The surface is aproximated by Bezier - Bernstein polynom of the 5th grade. This polynom can be expressed in a matrix form

$$r_i = u_i^T K_i v_i \quad , \quad i = 2, 3 \tag{1}$$

where u_i, v_i, are the column matrices with scalar parameters u, v ∈ <0, 1> and K = MBN. The matrices M, N, contain coeficients of Bezier polynoms, the matrix B contain the components of position vectors of apexs controlling polygon. This polygon has four common apexs with the aproximated surface with tangent contact.

In the program block DOTYK the point of contact two meshing surfaces is looked so, that for the given position of one mem-ber ($\varphi_2 = \varphi_{20}$) the angle of the second member is calculated. The solution is based on the determination of the minimum of the result function F (for the set of parameters u_2, v_2, u_3, v_3, φ_3).

$$F = (r_2 - \Pi_{32}\, r_3)^2 + k\left[\Pi_{32}\left(\frac{\partial r_3}{\partial u} \times \frac{\partial r_3}{\partial v}\right) \times \left(\frac{\partial r_2}{\partial u} \times \frac{\partial r_2}{\partial v}\right)\right] \tag{2}$$

where Π_{32} is the transformation matrix. In the point of contact L, see fig. 2.

$$r_L = \begin{bmatrix} a - x_2 \cos\varphi_2 - y_2 \sin\varphi_2 \\ b + z_2 \\ x_2 \sin\varphi_2 - y_2 \cos\varphi_2 \end{bmatrix} ; \quad n_L = \begin{bmatrix} -n_{2x} \cos\varphi_2 - n_{2y} \sin\varphi_2 \\ n_2 \\ n_{2x} \sin\varphi_2 - n_{2y} \cos\varphi_2 \end{bmatrix} \tag{3}$$

where R ≡ x, y, z is the basic space, it is necessary to determine all known data from the local analysis. These data are necessary to perform the analysis. Therefore the vector direction of the base t, n, ν and the quantities R_{Pi}, β_{Pi}, δ_i, α, for i = 2, 3 in this base have to be determined. The transversal line between the axis o_2, o_3 is puted through the point of contact P ≡ L. The plane τ, perpendicular to this line, contains, see fig. 3, the contact point P.

From the equation

$$(a - b_2\ o_2 - r) \times (b_3\ o_3 - r) = 0\ , \quad \text{where } r = r_L, \tag{4}$$

b_2, b_3 can be obtained and from the equation

$$\overline{C_2C_3}\ \nu_o = b_3\ o_3 - a + b_2\ o_2 \tag{5}$$

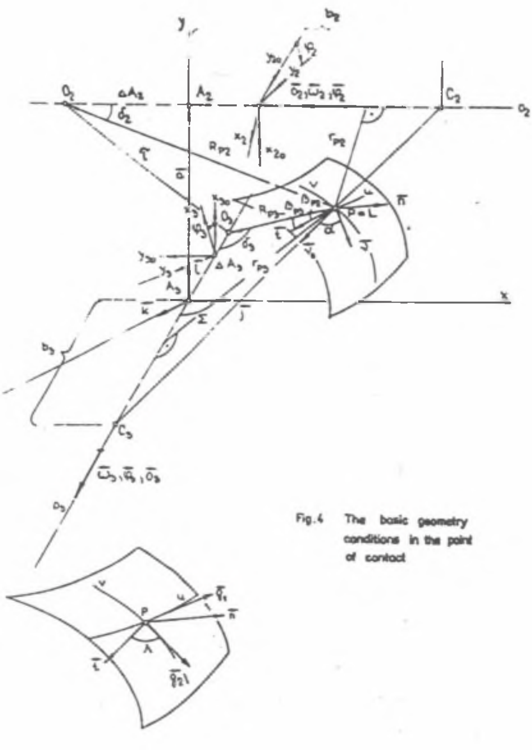

Fig. 4. The basic geometry conditions in the point of contact
Rys. 4. Podstawowe warunki geometryczne w punkcie zetknięcia

the vector of the main normal ν_o can be expressed. From the relation $r = a - b_2\ o + \overline{PC}_2\ \nu_o$, $r = b_3\ o_3 - \overline{PC}_3\ \nu_o$

$$\cos\left(\frac{\Pi}{2} - \delta_i\right) = o_i\ \nu_o\ , \quad i = 2,\ 3 \tag{6}$$

it is possible expressed $\overline{PC}_2$, $\overline{PC}_3$, δ_2, δ_3. Further we determine

$$R_{Pi} = \frac{\overline{PC}_i}{tg\delta_i}\ , \quad \Delta A_i = \frac{\overline{PC}_i}{\sin\delta_i} - b_i\ ; \quad i = 2,\ 3 \tag{7}$$

The direction vectors are given

$$t = \frac{\nu_o \times n}{|\nu_o \times n|}, \quad \nu = n \times t, \quad \cos\alpha = \nu \cdot \nu_o \tag{8}$$

From the scalar product $R_{Pi} \cdot t$ the angels β_{Pi}, i = 2, 3, can be determinated. Then the basic geometry situation in the point of contact is defined. Now it is possible to perform in this point the local analysis. In the case, that the axis o_2, o_3 are para-llel or concurrent, it is necessary to perform a new solution.

In the program block KRIV the tensor of curvature of the plane in the point of contact is determined. The component of tensor are expressed in the local carthesian system P, t, n, ν

$$M_i = \begin{bmatrix} N_1 & G & 0 \\ G, & N_2, & 0 \\ 0 & 0 & 0 \end{bmatrix}, \quad i = 2, 3 \ . \tag{9}$$

The normal curvature N and the geodetic curvature G are defined with the help of the local carthesian system P, g_1, g_2, where $g_1 = \frac{\partial r}{\partial u}$, $g_2 = \frac{\partial r}{\partial v}$. The all quantities are expressed in the space R_2, which is connected with the member 2. In the program block ZPO the analysis in the mesh point is performed and further the sensitivity of the higher kinematic pair to the relative change ofaxis. Also the change of the change ratio is determined as a function of the axis translation.

REFERENCES

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Recenzent: Prof. Eugeniusz Świtoński

Wpłynęło do Redakcji dnia 18.11.1992

Streszczenie

W artykule niniejszym opisano krótko zbiór programów do analizy pary kinematycznej wyższego rzędu, która jest częścią mechanizmu trójczłonowego. Proponowany zbiór programów pozwala użytkownikowi na dokonanie miejscowej analizy w dowolnym punkcie zetknięcia dwóch powierzchni. Parametry wejściowe można otrzymać zarówno na drodze obliczeniowej, jak i pomiaru. Zbiór programów jest sterowany za pomocą programu głównego. Program ten umożliwia użytkownikowi operowanie całym zestawem programów w prosty sposób, bez konieczności rozumienia zagadnień koniecznych do obliczeń.