Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 14th International Scientific and Practical Conference. Volume 3, 168-171

A Geometrical Synthesis of Comez Textile Mechanisms of Finally Removed Possibilities

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***Abstract*. A synthesis of the COMEZ spatial knitting mechanism has been developed to convert rotational motion around a moving axle in a reciprocating motion. The synthesis has been done in extremely remote positions. For practical application of the synthesis, a vector-matrix approach is proposed in Math LAB Watt programming environment. With the specific metric parameters of the head mechanism, the function definition of the position is considered and a proposed eight-pointed mechanism replacing the spatial hump of the knitting head is proposed. To establish the authenticity of synthesis is an example.**

Keywords: Circular knitting mechanisms, metric synthesis at far-off positions, geometrical synthesis, functions of the position.

I. INTRODUCTION

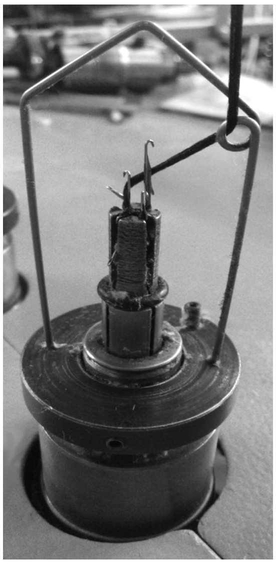

Fig.1 Real circular knitting head mechanism.

The metric synthesis of the **CKM** (Circular knitting mechanism) at extremely remote positions can be done by the vector-matrix method, using the generalized approach applied to planar lever mechanisms out of phase by 120° [1, 4, 5, 6, 7 and 8].

Figure 1 shows a **COMEZ** basic mechanism operating with three vertical needles, and Figure 2 shows the kinematic diagram of the head of the same mechanism with two symmetrical needles. This mechanism is designed to entangle a textile thread into a diameter of a line. What will be the diameter of the thread, as well as its roughness, depends on the number of entangling needles and the diameter of the hole in the middle of the head.

In order to improve the present mechanism, it is necessary to synthesize metrically and kinematically, by means of the vector-matrix method, a new structure which would create the possibility of entangling a cord from random textile threads.

The example illustrates a knitting head synthesis used in COMEZ textile machines where the main problem is the poor entanglement of thin artificial fibers caused by the high values of the accelerations at characteristic points in the movement of the knitting needle.

In order to make an optimal synthesis of the indicated mechanism with subsequent kinematic analysis and to ascertain the effect of the synthesis, the following activities were carried out:

1. Replacement of the spatial mechanism with an eight-plane flat lever mechanism was made, the function of the position of the initial and of the provided mechanisms being the same.

2. A eight-legged mechanism has been synthesized,

Print ISSN 1691-5402
Online ISSN 2256-070X
https://doi.org/10.17770/etr2023vol3.7187

which has been studied in detail in the characteristic points.

3. Draw kinematic schemes for the same positions.

4. The initial and conceded mechanisms are compared, each figure depicting the function of the change of the relative error of the executive unit between the initial and the resulting mechanisms.

5. The peak values of the linear accelerations of the executive unit at the characteristic points of the mechanism are minimized.

6. The author propose a unified approach to the synthesis of such mechanisms at extreme discrete positions (marginal synthesis M-synthesis) that can be applied to different types of mechanisms, both for guiding and for moving mechanisms.

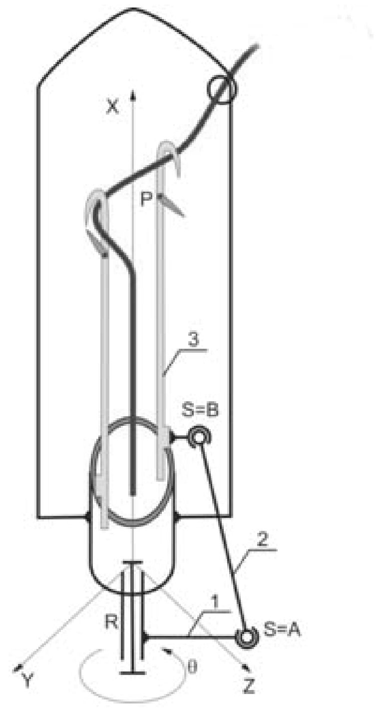

Fig.2 Kinematic diagram of a circular knitting mechanism.

II. Materials And Methods

II.1. Synthesis of a COMEZ mechanism intended for the Math LAB Watt programming environment.

1. Enter the relative linear displacements $\mathbf{S}_{1i}$ of the center of the spherical pair **B**, the relative angular orientations $\boldsymbol{\theta}_{1i}$ of link 1, the limits and steps of change of the variable parameters.

2. Enter the expressions:

$$\begin{bmatrix} X'_{Bi} \\ Y'_{Bi} \\ Z'_{Bi} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{1i} & \sin\theta_{1i} \\ 0 & -\sin\theta_{1i} & \cos\theta_{1i} \end{bmatrix} \begin{bmatrix} X_{B_1} + S_{i1} \\ Y_{B_1} \\ Z_{B_1} \end{bmatrix} \quad (1)$$

to determine the coordinates $X_{B'_i}$, $Y_{B'_i}$ and $Z_{B'_i}$ of the center of the spherical pair **B**.

3. Enter the expressions:

$$\begin{aligned} a_i &= 2S_{1i} \quad , \\ b_i &= -2(Y_{B'i} - Y_{B1}) \ , \\ c_i &= -2(Z_{B'i} - Z_{B1}) \ , \\ d_i &= Y_{B1}^2 + Z_{B1}^2 - Y_{B'i}^2 - Z_{B'i}^2 - S_{1i}^2 , \ i = 2,3,...,n \end{aligned} \quad (2)$$

to determine the coefficients of the system of equations: $a_i X_{B_1} + b_i Y_{A_1} + c_i Z_{A_1} = d_i$.

4. With **n=5** and one variable parameter, the functions are entered

$$\begin{aligned} X_{B_1} &= X_{B_1}(Y_{B_1}) \ , \\ Y_{A_1} &= Y_{A_1}(Y_{B_1}) \ , \\ Z_{A_1} &= Z_{A_1}(Y_{B_1}) \ . \end{aligned} \quad (3)$$

and

$$F(Y_{B1}) = a_5.X_{B_1} + b_5.Y_{A_1} + c_5.Z_{A_1} - d_5 \quad (4) .$$

The graphs of these functions are drawn and the values of the variable and the computational parameters are determined from them.

5. With **n=5** end two variable parameters, the functions are introduced

$$\begin{aligned} X_{B_1} &= X_{B_1}(Y_{B_1}, Z_{B_1}) \ , \\ Y_{A_1} &= Y_{A_1}(Y_{B_1}, Z_{B_1}) \ , \\ Z_{A_1} &= Z_{A_1}(Y_{B_1}, Z_{B_1}) \ . \end{aligned} \quad (5)$$

$$F(Y_{B1}, Z_{B1}) = a_5 X_{B1} + b_5 Y_{A1} + c_5 Z_{A1} - d_5 \ (6).$$

The isoline of the surface determined by the function (6) is drawn for zero values of this function. With the coordinates of points of this isoline (which are values of the variable parameters) and the functions (5), the calculation parameters are determined.

6. With **n=6** and two variable parameters, the functions (5) and

$$\begin{aligned} F(Y_{B1}, Z_{B1}) &= a_5 X_{B1} + b_5 Y_{A1} + c_5 Z_{A1} - d_5 \ , \\ Q(Y_{B1}, Z_{B1}) &= a_6 X_{B1} + b_6 Y_{A1} + c_6 Z_{A1} - d_6 \ . \end{aligned} \quad (7)$$

The isolines of the surfaces determined by the functions (7) are drawn. The coordinates of their intersection points (which give the values of the variable parameters) are calculated from them and the calculation parameters are determined with them and the functions (5).

III. RESULTS AND DISCUSSION

Example: To synthesize a ***COMEZ*** lever mechanism for driving the working head of the knitting machine at set: $Z_{B1}=0,015m$; relative linear displacements $S_{12}=0,1m$, $S_{13}=0,023m$ $S_{14}=0,020m$, $S_{15}=0m$; relative angular orientations of the leading link $\theta_{12}=\pi/3$, $\theta_{13}=2\pi/3$, $\theta_{14}=\pi$, $\theta_{15}=2.\pi$.

Six discrete positions marked in Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7 and Fig. 8 is fixed. To synthesize and draw the kinematic scheme of an eight-link bent mechanism for each of the six positions of the executive unit (knitting needle).

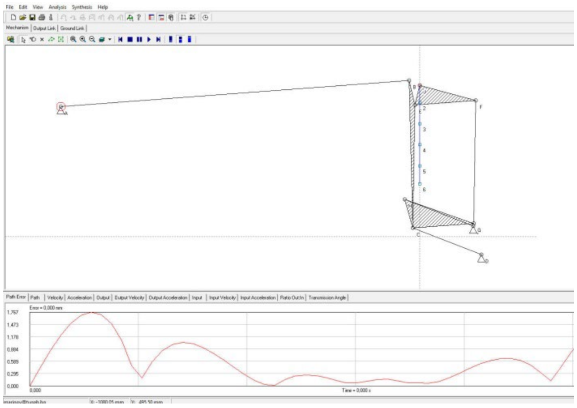

Fig.3 First extreme remote position.

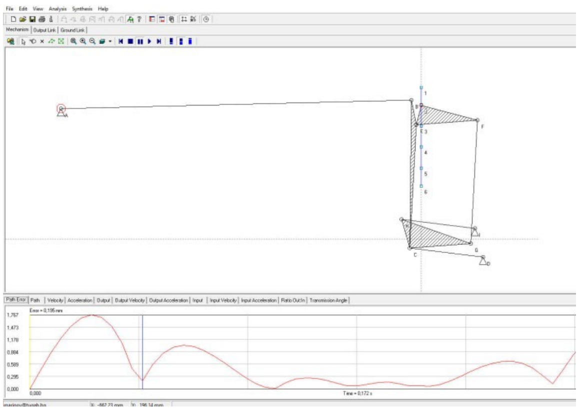

Fig.4 Second extreme remote position.

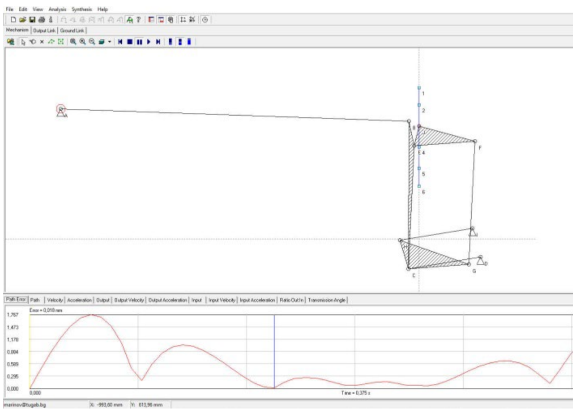

Fig.5 Third extreme remote position.

Fig. 2 shows the kinematic scheme of the knitting head, where the needles are controlled by a spatial cam, which is subsequently kinematically reduced to an eight-link lever mechanism, and the values of the variable parameter Y_{B1}=0,02m and the calculation parameters X_{B1}=0,02m, Y_{A1}=-0,015m, Z_{A1}=-0,037m.

In the lower part of the graphs, the relative error in the displacements of link **3** is plotted.

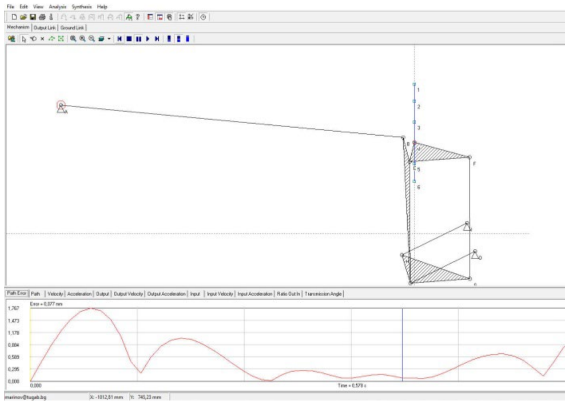

Fig.6 Fourth extreme remote position.

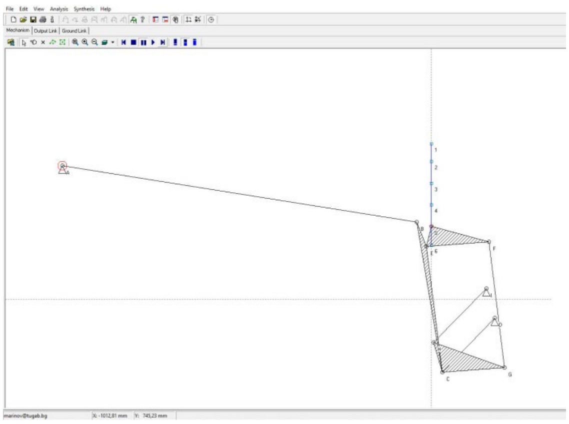

Fig.7 Fifth extreme remote position.

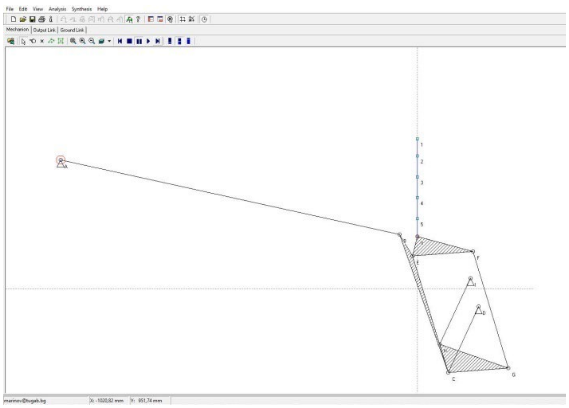

Fig.8 Sixth extreme remote position.

At the moment, a procedure for issuing a utility model (patent) has been launched at the Bulgarian Patent Office, related to increasing the capacity of the shown mechanism. This is a personal contribution of the author. It is related to studying the reliability of the displayed model. I dare to say that the synthesized mechanism is up to 15% more stable in operation than that of a company „COMEZ”.

The present problem "Geometric sybthesis of COMEZ textile mechanisms at extremely remote positions" is conditionally divided into two parts. 1. Mathematical model for synthesis at extremely remote positions (six in number) and published in this article. 2. Innovative technological prototype of the circular knitting head, which is described and verified for patent purity.

More comments about the number of needles used and their gauges are the subject of the utility model I am applying for and are not subject to comment on the math model.

Moreover, in figures 3 to 8, the graphs of the kinematic parameters are drawn, which give an idea to the specialist in the field about the phase diagrams of the textile entanglement.

IV. CONCLUSION

The example made shows the synthesis of a knitting head used in COMEZ textile machines, where the main problem is the poor entanglement of thin artificial fibers caused by the high values of the accelerations at characteristic points during the movement of the knitting needle, namely points 1,2,3, 4,5 and 6 shown in the above figures.

In order to make an optimal synthesis of the shown mechanism with subsequent kinematic analysis and to establish the effect of the synthesis, the following activities were carried out:

1. The spatial mechanism was replaced with an eight-link planar lever mechanism, while the function of the position of the initial and reduced mechanisms is the same.

2. An eight-link mechanism was synthesized, which was studied in detail in characteristic points 1, 2, 3, 4, 5 and 6.

3. The kinematic diagrams for the same positions are drawn (fig. 3, fig. 4, fig. 5, fig. 6, fig. 7 and fig. 8).

4. The initial and reduced mechanisms are compared, and in each figure the function of the change of the relative error of the executive unit between the initial and reduced mechanisms is plotted.

5. The peak values of the linear accelerations of the executive unit at the characteristic points of the mechanism are minimized.

6. The authors propose a unified approach for the synthesis of such mechanisms at finitely distant discrete positions (marginal synthesis M-synthesis), which can be applied to different types of mechanisms, both for guiding and moving mechanisms.

7. The obtained numerical results were obtained theoretically and based on them a prototype was developed, which shows increased performance compared to that of the existing models. The prototype of the mechanism is made in a real industrial environment.

Regarding the reviewer's comment that the literature used is old, I would like to say that these are the classics in the field of the theory of mechanisms and machines. Or to put it another way, the Pythagorean Theorem and Newton's laws are old and out of date.

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